TM11-1554

WAR DEPARTMENT TECHNICAL MANUAL

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RADIO SET SCR-784
SERVICE MANUAL

THEORY,
TROUBLE SHOOTING,
AND REPAIR

WAR DEPARTMENT *1 MARCH 1945*

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WASHINGTON 25, D. C., 1 MARCH 1945.

TM 11-1554, Radio Set SCR-784. Service Manual, is published for the information and guidance of all concerned.

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BY ORDER OF THE SECRETARY OF WAR:

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For explanation of symbols, see FM 21-6.

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WARNING

HIGH VOLTAGE

is used in the operation
of this equipment.

DEATH ON CONTACT

may result if personnel fail
to observe safety precautions.

Be careful not to contact high-voltage plate circuits or 115-volt a-c input connections while checking or servicing the equipment. Make certain that the power is turned off before disassembling any part of the equipment.

Dangerously high voltages are present in the power supplies of this equipment. High-voltage capacitors in these power supplies must be discharged manually when service checks are made after the a-c power has been removed from the components.

EXTREMELY DANGEROUS POTENTIALS

exist in the following units:

Driver Unit BC-1080-C
Indicator BC-1092-C
Indicator BC-1371
Oscillator BC-1374
Rectifier RA-69-A
Rectifier RA-72-A
Transmitter Frame Assembly BC-1373

FIRST AID TREATMENT FOR ELECTRIC SHOCK

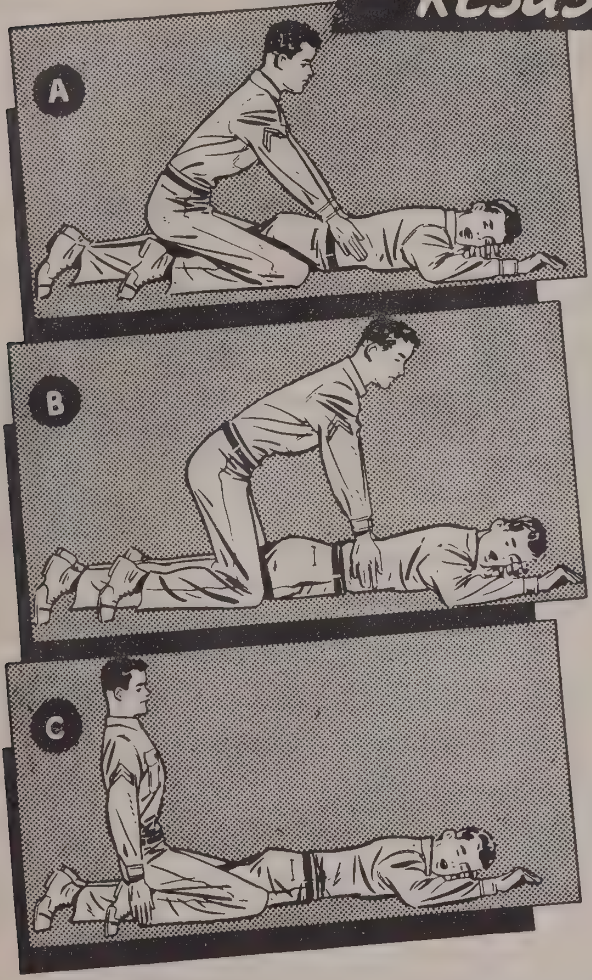
I. FREE THE VICTIM FROM THE CIRCUIT IMMEDIATELY.

Shut off the current. If this is not **immediately** possible, use a dry nonconductor (rubber gloves, rope, board) to move either the victim or the wire. Avoid contact with the victim. If necessary to cut a live wire, use an axe with a dry wooden handle. Beware of the resulting flash.

II. ATTEND INSTANTLY TO THE VICTIM'S BREATHING.

Begin resuscitation at once on the spot. Do not stop to loosen the victim's clothing. Every moment counts. Keep the patient warm; Wrap him in any covering available. Send for a doctor. Remove false teeth or other obstructions from the victim's mouth.

RESUSCITATION



POSITION

1. Lay the victim on his belly, one arm extended directly overhead, the other arm bent at the elbow, the face turned outward and resting on hand or forearm, so that the nose and mouth are free for breathing (fig. A).

2. Stradle the patient's thighs, or one leg, with your knees placed far enough from his hip bones to allow you to assume the position shown in figure A.

3. Place your hands, with thumbs and fingers in a natural position, so that your palms are on the small of his back, and your little fingers just touch his lowest ribs (fig. A).

FIRST MOVEMENT

4. With arms held straight, swing forward slowly, so that the weight of your body is gradually brought to bear upon the victim. Your shoulders should be directly over the heels of your hands at the end of the forward swing (fig.B). Do not bend your elbows. The first movement should take about 2 seconds.

SECOND MOVEMENT

5. Now immediately swing backward, to remove the pressure completely (fig. C).

6. After 2 seconds, swing forward again. Repeat this pressure-and-release cycle 12 to 15 times a minute. A complete cycle should require 4 or 5 seconds.

CONTINUED TREATMENT

7. Continue treatment until breathing is restored or until there is no hope of the victim's recovery. Do not give up easily. Remember that at times the process must be kept up **for hours.**

8. During artificial respiration, have someone loosen the victim's clothing. Wrap the victim warmly; apply hot bricks, stones, etc. Do not give the victim liquids until he is fully conscious. If the victim must be moved, keep up treatment while he is being moved.

9. At the first sign of breathing, withhold artificial respiration. If natural breathing does not continue, immediately resume artificial respiration.

10. If operators must be changed, the relief operator kneels behind the person giving artificial respiration. The relief takes the operator's place as the original operator releases the pressure.

11. Do not allow the revived patient to sit or stand. Keep him quiet. Give hot coffee or tea, or other internal stimulants.

HOLD RESUSCITATION DRILLS REGULARLY

DESTRUCTION NOTICE

WHY —To prevent the enemy from using or salvaging this equipment for his benefit.

WHEN —When ordered by your commander.

HOW —1. Smash—Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools.
2. Cut—Use axes, handaxes, machetes.
3. Burn—Use gasoline, kerosene, oil, flame throwers, incendiary grenades.
4. Explosives—Use firearms, grenades, TNT.
5. Disposal—Bury in slit trenches, fox holes, other holes. Throw in streams. Scatter.

USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT.

WHAT —1. Smash—Transmission line, antenna assembly, transmitter, magnetron, all tubes, meters, variable capacitors, relays, spare parts, and engine unit generator.
2. Cut—All cables, knobs and dials on face of chassis.
3. Burn—All buildings, tower, and all technical manuals.
4. Bury or scatter—Remains of magnetron and all other parts after destroying their usefulness.

DESTROY EVERYTHING

REFERENCE NOTICE

TM 11-1554, SERVICE MANUAL, is one of three technical manuals on Radio Set SCR-784. It is used on conjunction with TM 11-1354, TECHNICAL OPERATION MANUAL, and TM 1454, PREVENTIVE MAINTENANCE MANUAL. TM 11-1554 contains two general types of information. First, it explains the theory of operation of Radio Set SCR-784; and second, it supplies practical procedures to be followed when the equipment fails to function properly. The SERVICE MANUAL serves as a guide for locating the source of trouble, indicates the proper repair or replacement necessary, and in general assists the technician in charge to get the radar set back into service.

The theory section of this manual is written for personnel who have a general knowledge of radar. Less experienced personnel will be assisted in the use of the manual by reference to TM 11-466, which covers the fundamental principles of radar and the electronic theory necessary for a further study of radar, and to TM 11-467, which covers common radar systems in use.

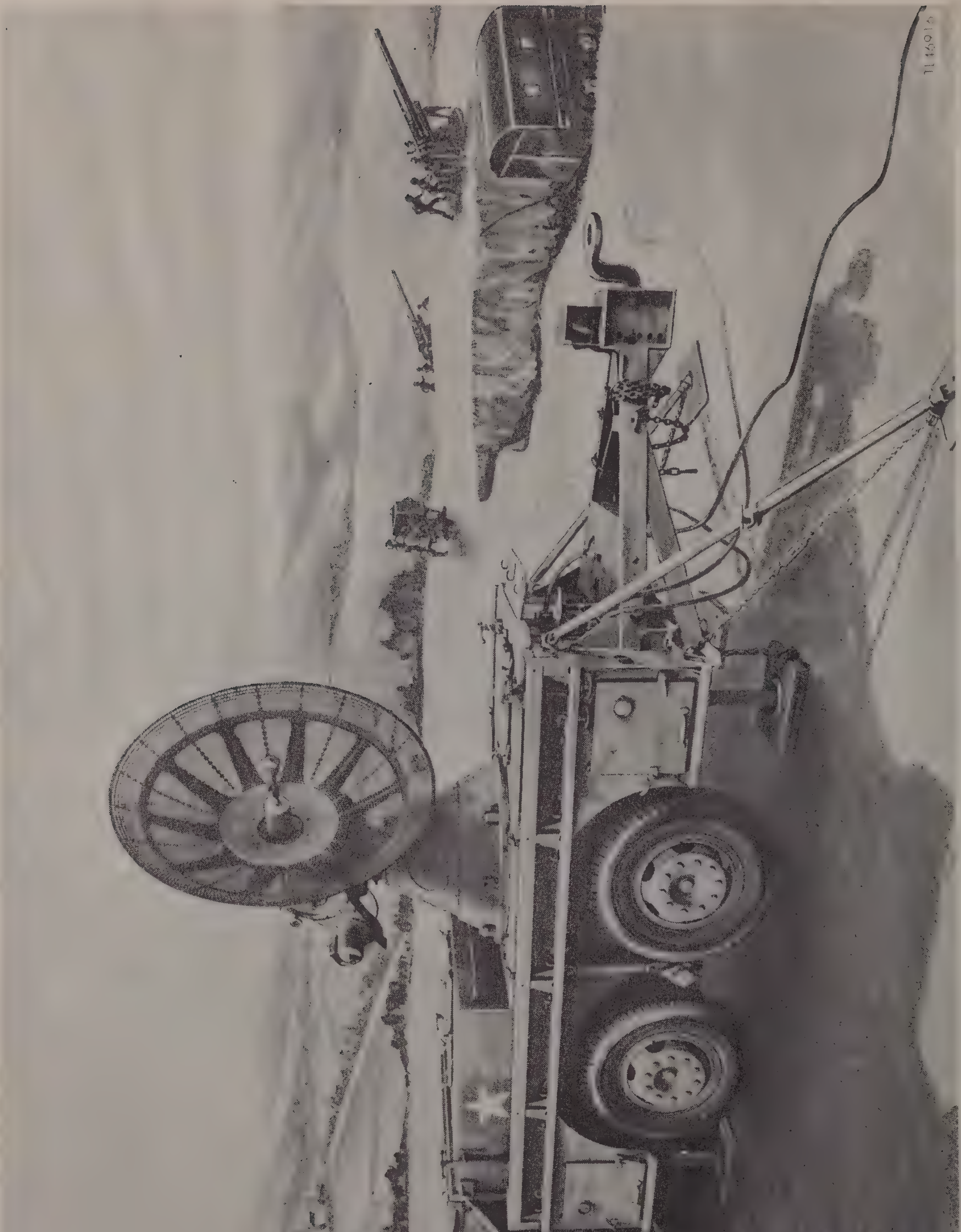


Figure 1. Radio Set SCR-784.

PART ONE
THEORY

CHAPTER 1
GENERAL DESCRIPTION

SECTION I
INTRODUCTION

1. USE.

The basic function of Radio Set SCR-784, in common with other radar sets, is radio detection and ranging. It can search for and detect airplanes within its effective range of 70,000 yards. However, after locating a target, the primary function of the SCR-784 is to follow (track) the target and provide accurate and exact present-position (tracking) information for use with antiaircraft artillery. Within a range of 32,000 yards the SCR-784 will follow a target automatically, and within a range of 28,000 yards it will supply the directors information on the azimuth, elevation, slant range, and altitude of the target. Radio Set SCR-784 is a mobile radar unit mounted in a standard Army trailer. Being mobile, it may be readily moved to new locations, depending on the tactical situation, and rapidly set up to provide the required data. The chief functions of the set, all related to antiaircraft activity, are:

a. To search for approaching targets.

b. To track a selected target automatically.

c. To generate voltages which continually represent the azimuth, range, height, and elevation-angle positions of the target, and to determine these positions within very small margins of error.

d. To furnish these position voltages to the gun director which aims the antiaircraft guns.

2. SEARCHING.

Searching, as related to Radio Set SCR-784, is the act of scanning an area in an effort to discover (pick up) a target. The SCR-784 is equipped to perform this searching operation by continuous azimuth scanning, helical scanning, or manual scanning.

a. Continuous Azimuth Scanning (fig. 2). The word "continuous", in the continuous azimuth scanning method of searching, refers only to the azimuth movement of the antenna. The antenna is set at the desired angle of elevation and a motor is used to rotate the antenna in a complete circle in azimuth. The velocity of a radio wave is so much greater than the speed at which the antenna rotates, that a transmitted pulse can leave the antenna, go out to the target at point 1, reflect from the target, and return before

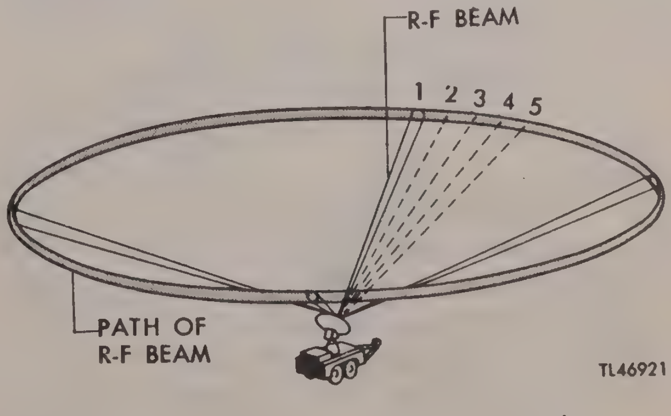


Figure 2. Continuous azimuth scanning.

the antenna has had time to turn to point 2. The returned pulse (target echo) is then displayed on a PPI scope and appears as a bright patch of light at the azimuth in which the antenna is pointing. Thus the target is discovered, located, and can be followed (tracked).

b. Helical Scanning (fig. 3). In order to obtain greater coverage of the space surrounding the radar set, helical scanning is used. In continuous azimuth scanning the antenna was set at a certain elevation angle, with the result that a plane flying above or below the r-f beam would escape discovery. In helical scanning the antenna not only rotates in azimuth but also rises automatically 54 mils in elevation for every revolution of the antenna in azimuth. After the angle of elevation has increased 356 mils (20 degrees), the antenna drops back to its original elevation position and the cycle begins again. In this way the radio beam searches much more of the surrounding area, and any plane in the area will be detected.

c. Manual Scanning. When the tactical situation requires that only a small sector of the surrounding area be searched, manual scanning is used. The antenna is moved manually in azimuth and elevation by means of handwheels to search the desired sector.

3. TRACKING.

Tracking, as related to Radio Set SCR-784, is the act of following a moving target so that information as to its azimuth, elevation, height, and range position at any instant is always available.

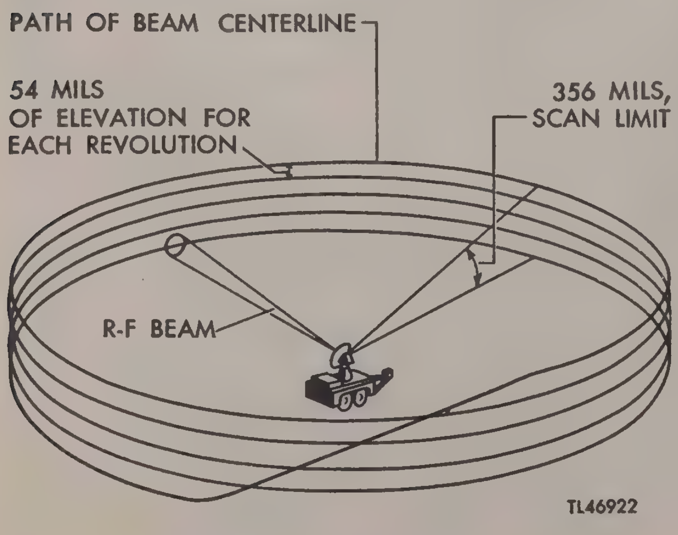


Figure 3. Helical scanning.

a. Azimuth and Elevation.

(*1*) A target may be tracked manually from the indications on the PPI and range scopes but this manual tracking method is not satisfactory for transmitting information on the target's position to the gun director. When this information is to be furnished the gun director, automatic tracking in azimuth and elevation is used.

(*2*) In order to provide a control voltage to make the antenna follow the target automatically, conical scanning is used. The r-f beam itself is made to rotate and an error voltage is generated to control the position of the antenna. The magnitude of this error voltage depends on the position of the r-f beam in respect to the position of the target.

(*3*) The antenna dipole is not completely symmetrical; so the antenna radiates a beam which is slightly offset from the axis of the reflector. Rotation of the antenna dipole with a spinner motor at a fixed rate produces a cone of r-f beams so that conical scanning is accomplished. A similar scanning action could be produced by spinning the lamp in an ordinary automobile headlight while the "dim" filament is burning. The dim filament is offset from the center of the lamp and thus from the center of the reflector. As a consequence, the dim light beam angles down toward the ground. If the lamp could be rotated in its socket, the light beam would scan a conical area.

(*4*) The magnitude of the error voltage generated depends on the relative strengths of echoes received from a specified target during conical scanning. In figure 4, the center of the beam is shown at position 1 on the beam's circular path. Three other positions on the path (2, 3, and 4) are indicated. A plane in position A receives r-f pulses of equal strength, regardless of the position of the scanning beam. This makes the reflected echoes received at the radar set of equal strength and produces an error signal of zero amplitude. The reflector is "on target"; it is already correctly positioned. If the plane moves to position B, it now receives and reflects equal amounts of energy when the beam is in positions 2 and 4, but more energy when the beam is in position 3 than when it is in position 1. In general, the echoes received at the radar set are stronger when the scanning beam is above a line drawn through positions 2 and 4. This means that the reflector must be tilted down in order to bring it "on target".

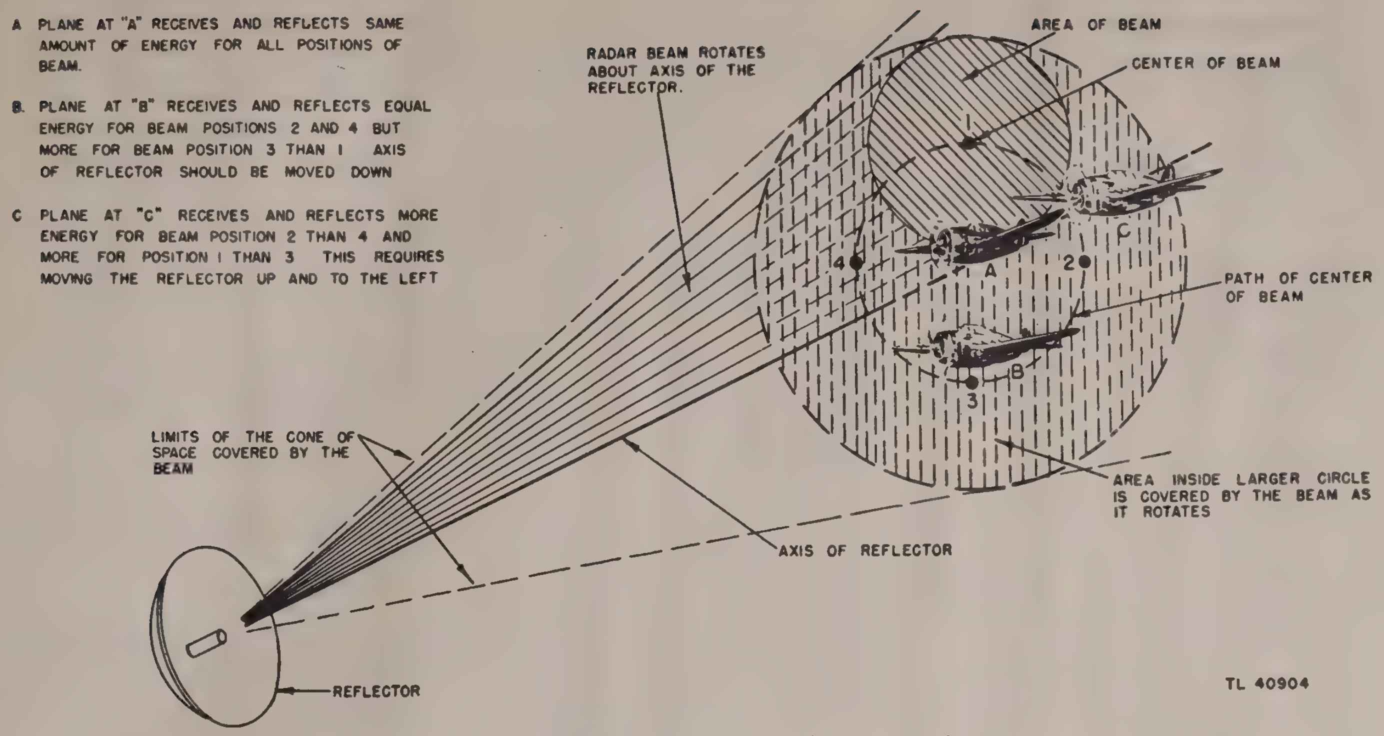


Figure 4. Pictorial view of conical scanning.

The error signal shows this relationship of the plane to the reflector's axis. With the plane in position C, it receives stronger pulses when the beam is in position 2 than when it is in position 4, and also stronger pulses when the beam is in position 1 than when it is in position 3. The reflected and received echoes are correspondingly weak and strong, and the error voltage produced is in proportion to the weakness and strength of the echoes. In this case the reflector must be tilted up and to the left to bring it "on target".

(*5*) The magnitude of the error signal always depends on the relative strengths of the echoes received. Since scanning is continuous, the error signal is developed continually, and it is combined with each of two "reference voltages". One of these combinations depends upon the up-down position of the scanning beam, and the other combination depends upon the right-left position of the beam. The two separate combinations become two "control voltages" which automatically drive the antenna-positioning motors in the direction and at the speed which enables the antenna to follow the target.

b. Range. Range tracking can be manual, aided, or automatic. Any one of these three methods may be used when tracking a target automatically in azimuth and elevation.

(*1*) Manual or aided range tracking can be used with either the narrow (NORMAL) or N^2 (ART) gate on the range scopes. The only difference between these two gates is that the N^2, i.e., narrow narrow, gate is only 50 yards wide and must be held more accurately on the target to follow a target automatically in azimuth and elevation.

(*a*) In manual range tracking the range hairline is kept at the leading edge of the target echo on the range scope by means of a slewing handwheel.

(*b*) With aided tracking, the operator controls the speed of the range motor which rotates the hairline. A tracking handwheel is so adjusted that the rate at which the hairline moves around the scope is directly proportional to the rate at which the target changes its distance from the radar set.

(*2*) With automatic range tracking only, the N^2 gate is used. Automatic range tracking is used only in conjunction with automatic or remote tracking in azimuth and elevation. Here the position of the target echo with respect to the range hairline controls the speed at which the range motor rotates the hairlines.

4. DATA TRANSMISSION.

The information (data) as to the target's azimuth, elevation, slant-range, and altitude position is obtained during tracking. Potentiometers and selsyns, connected to the antenna mount and range hairlines, transmit this data through cables to the gun director, where it is used to control the position and firing range of antiaircraft guns.

5. TECHNICAL CHARACTERISTICS.

The principal technical characteristics of Radio Set SCR-784 are as follows:

RANGE	
Maximum: PPI search	70,000 yards.
Automatic tracking	32,000 yards.
Potentiometer data	28,000 yards.
Minimum	500 to 1,000 yards.
Accuracy at maximum range	± 25 yards.
Determination	By the interpretation of time difference between the instant of transmission of main pulse and arrival of echo pulse on PPI scope and range scopes.
AZIMUTH	
Coverage	360° or any particular sector of 360° (depending on the tactical situation).
Accuracy	± 1 mil.
Determination	By direct reading on the azimuth dial. By the angular displacement of PPI sweep line in relation to a definite reference point.
ELEVATION	
Coverage	From 175 mils below horizontal to 1,600 mils above horizontal.
Upper limit	+ 1,600 mils.
Lower limit	– 175 mils.
Accuracy	± 1 mil.
Determination	By the direct reading of the elevation dial.
HEIGHT	
Coverage	300 to 10,000 yards.
Maximum	10,000 yards.
Minimum	300 yards.
Accuracy	± 10 yards.
Determination	By direct reading of slant range-altitude dial and direct reading of altimeter.
SEARCHING OPERATIONS	
Manual	Positioning of the antenna by means of the AZIMUTH and ELEVATION handwheels.
PPI scan	Automatic positioning of the antenna in a helical or rotary motion.
TRACKING OPERATIONS	
Azimuth and elevation	
Manual	Maximizing target echo on range- and PPI-scope screens by means of AZIMUTH and ELEVATION handwheels.
Automatic	By a controlling error signal that positions the antenna in azimuth and elevation.
Range	
Manual (Normal or ART)	Positioning the range-scope hairlines and narrow or N^2 gate on target echo by means of the SLEWING handwheel.
Aided tracking (Normal or ART)	Positioning of the range hairlines and narrow or N^2 gate on the target echo by a motor whose speed is varied by the TRACKING handwheel.
Automatic (ART)	Automatic positioning of the range-scope hairlines and N^2 gate in relation to the position of the target echo.

TYPE OF PRESENTATION	PPI presentation on a 7-inch cathode-ray tube. Range determined on two 3-inch cathode-ray tubes with circular time-base.
IFF	Use of an RC-384.
FREQUENCY	2,800 megacycles.
WAVELENGTH	10.7 centimeters.
PACKING OF EQUIPMENT	See TM 11-1354, Technical Operation Manual.
DIMENSION OF SITE	At least 20 x 25 feet.
TRANSMITTER SYSTEM	
Peak power	250 kilowatts.
Average power	600 watts.
Pulse recurrence frequency	1,707 pulses per second.
Pulse width	0.8 microsecond.
Modulator	Vacuum-tube modulator.
Source of r-f power	Magnetron.
RECEIVER SYSTEM	
Local oscillator	Type 417 klystron.
T-R tube	Type WE 721-A.
Intermediate frequency	30 megacycles.
Band width	2 megacycles.
R-F SYSTEM	
Transmission line	Coaxial.
Directional-antenna array	Beam concentration by 6-foot parabola.
Beam width	4 degrees at half-power points.
DATA TRANSMISSION	
M4 or M7 directors	Transmits selsyn data on azimuth, elevation, and either altitude or slant range.
M9 or M10 directors	Transmits potentiometer data on slant range, horizontal range, altitude, and east-west and north-south components of horizontal range.
	Transmits selsyn data to tracker on azimuth and elevation.

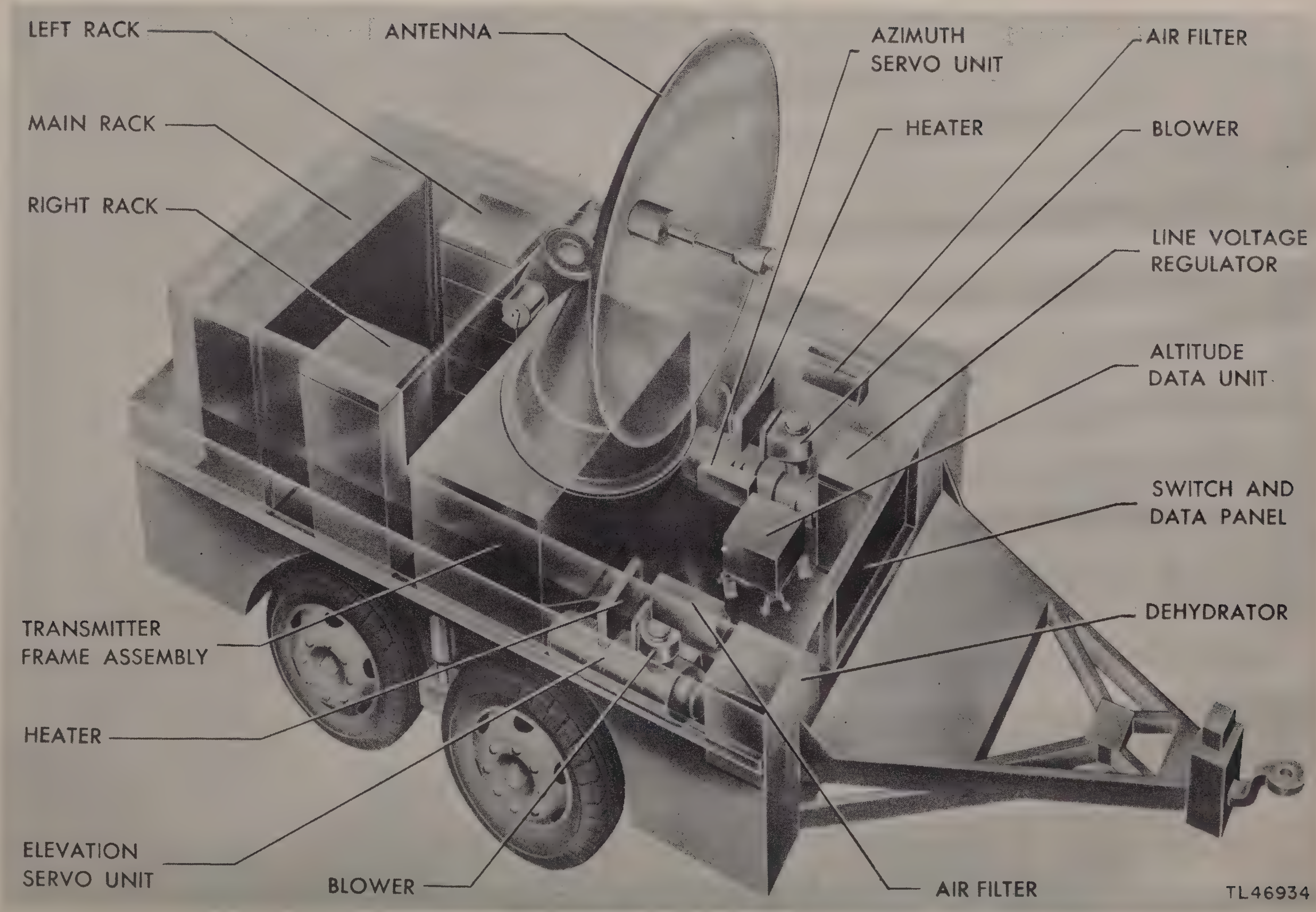


Figure 5. Trailer, phantom view.

SECTION II
DESCRIPTION

6. GENERAL.

Radio Set SCR-784 is mounted in trailer K-84. When in transit the trailer is drawn by a standard U. S. Army prime mover. The rear end of the trailer body is a door hinged at the top, with support arms for holding it open at a 90° angle from the closed position. A small door at the front end of the trailer body covers the switch and data panel. Two covered hatchways on top of the trailer permit access to the interior. The entire trailer body is watertight. Each wheelhouse contains two storage boxes, one at each end. The trailer is divided into two areas: a large area at the rear with the roof high enough to accommodate the main rack and the right and left racks, and a smaller area at the front for the other components. The antenna is mounted permanently on top of the trailer. The contents of the trailer are shown in figure 5.

7. MAIN RACK (fig. 6).

The main rack occupies the entire rear end of the trailer, and is made accessible by lifting the door which forms the rear end of the trailer.

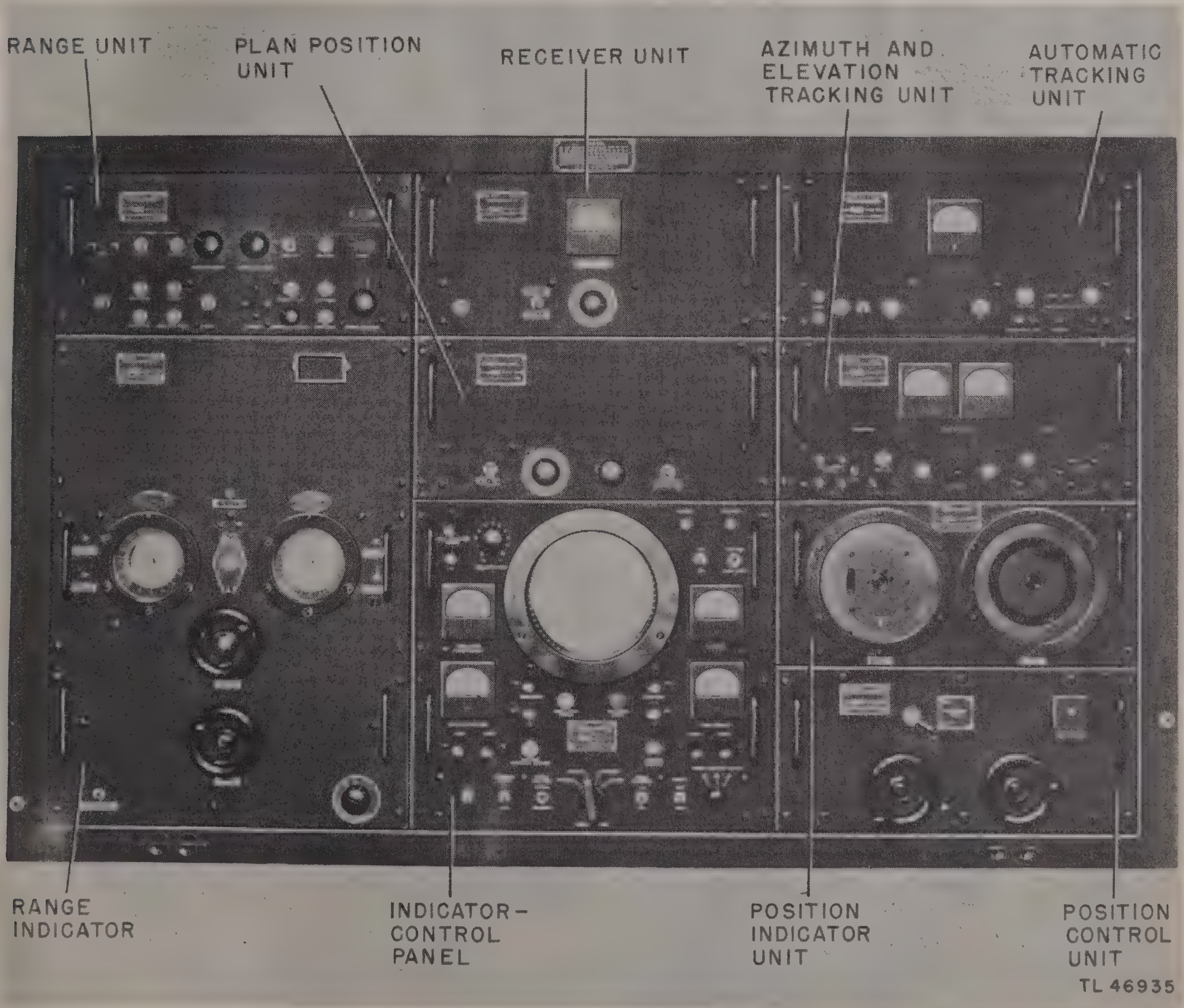


Figure 6. Main rack, showing components.

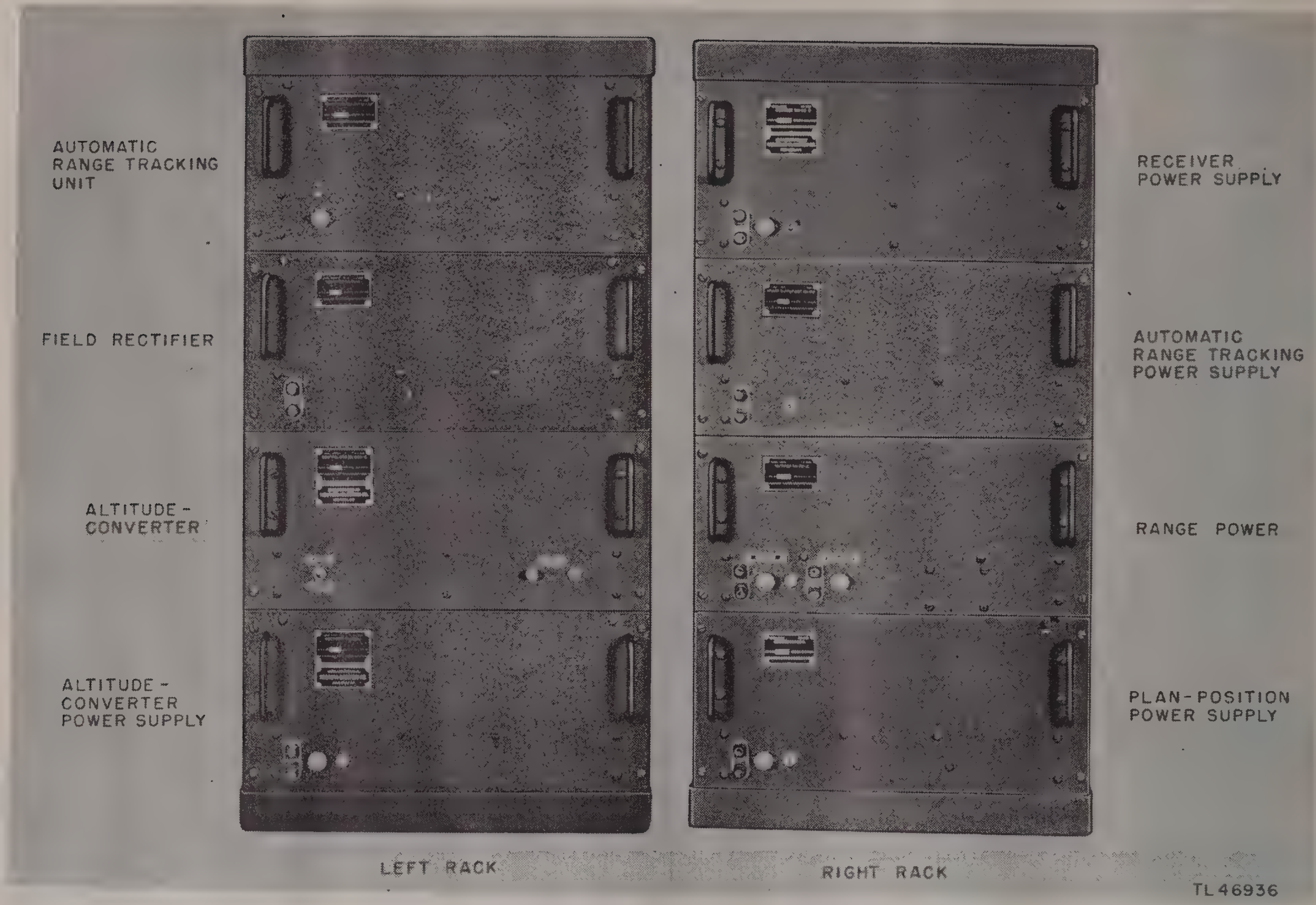


Figure 7. Right and left racks.

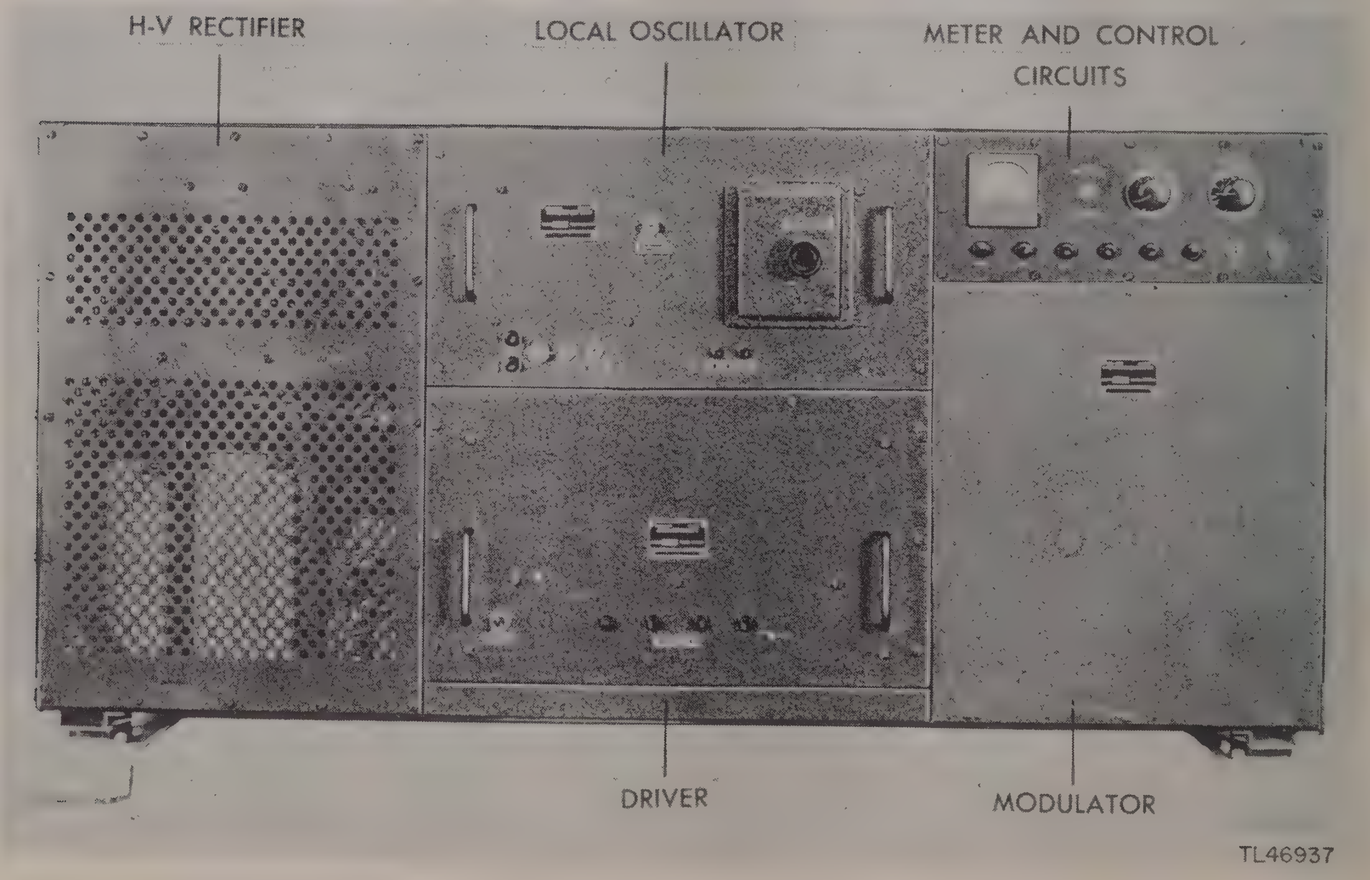


Figure 8. Transmitter frame assembly.

A front view of the main rack, with all of the components identified appears in figure 6. All of the components in the main rack assembly are on separate chassis and may be removed individually for replacement or repair of parts. The main rack contains all the operating controls and components which must be kept under observation during operation. The indicating units and operating controls are located in the lower portion of the main rack where they are convenient for observation and manipulation by the operator.

8. RIGHT AND LEFT RACKS (fig. 7).

The right and left racks are located one on each side of the trailer and in front of the main rack, and are not easily accessible during operation. Each rack contains four separate chassis (fig. 7) containing power supplies and operating units whose controls are brought out to the main rack on the indicator-control panel. Each chassis is removable and can readily be taken from the rack and through the rear hatchway in the roof.

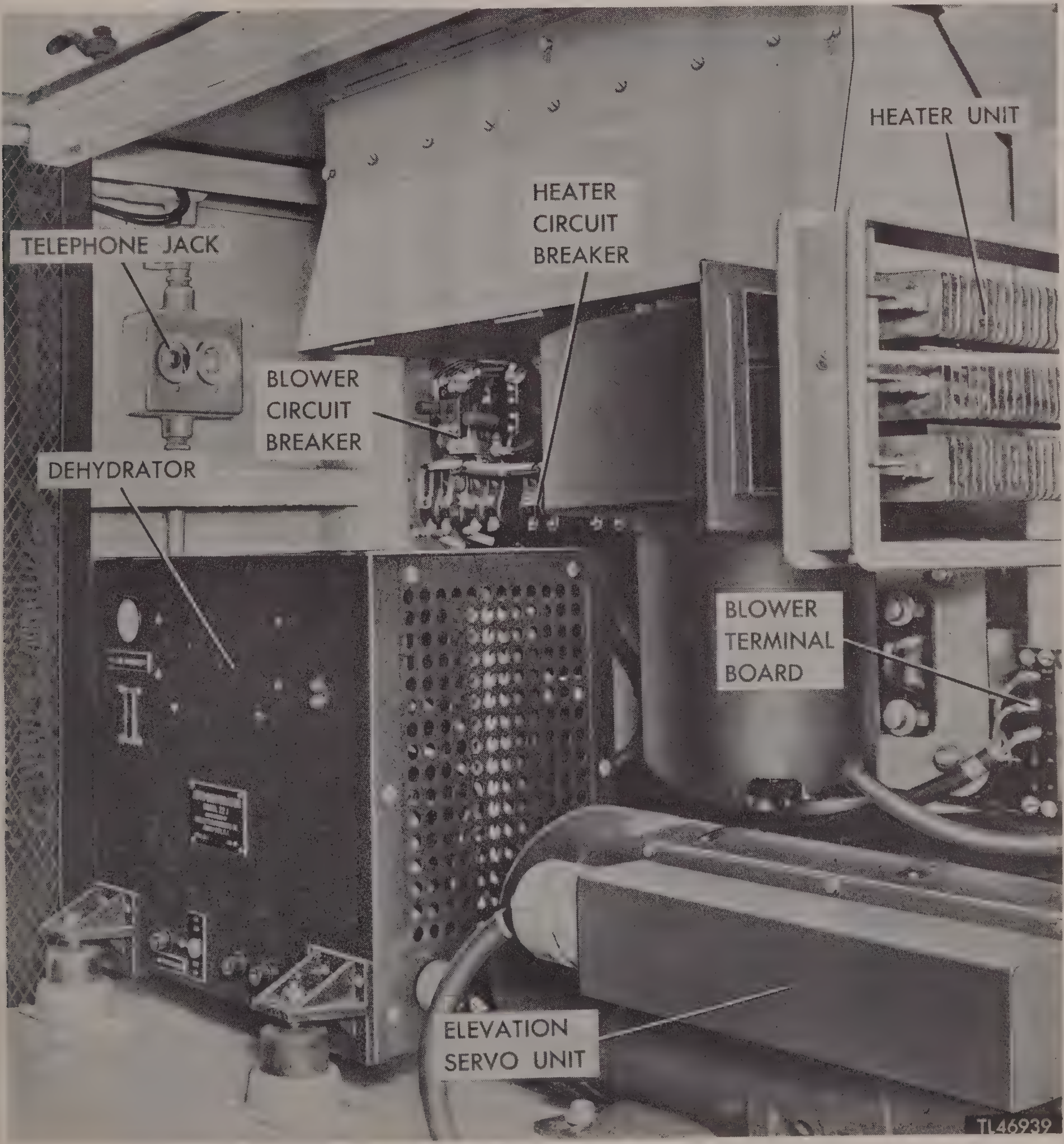


Figure 9. Interior of trailer, showing components.

9. TRANSMITTER FRAME ASSEMBLY (fig. 8).

The transmitter frame assembly is located in the central part of the trailer. The front portion of the transmitter, including the front panel, extends into the higher section of the trailer. This arrangement makes the front of the left and right racks, and the front panel of the transmitter readily accessible when the trailer is entered through the rear top hatch. In addition to the transmitting system components, the transmitter frame assembly also contains the local oscillator and preamplifier of the receiving system.

10. TRAILER MOUNTED UNITS (fig. 9).

a. The azimuth and elevation servo motor-generators are located on each side of the trailer in front of the transmitter frame assembly. They are mounted on the trailer floor, the elevation servo on the right side of the trailer and the azimuth servo on the left side. A small hatch is located on the top of the trailer between these two servo units permitting entrance to the front section of the trailer.

b. A blower and a heater unit are located in front of each ventilation intake and above each servo. This ventilating system keeps the operating temperature within optimum limits and provides filtered air to prevent injury to the components by dust and sand. The data unit is mounted on the floor of the trailer and next to the blower on the road side. The line voltage regulator is located at the front of the trailer on the road side. A light fixture and a 115-volt a-c receptacle is mounted on the front wall of the trailer above the line voltage regulator. The dehydrator is located at the front of the trailer on the curb side. A light fixture and intercommunication phone jacks are mounted on the front wall of the trailer and above the dehydrator. Controls for these units are brought out either to the switch and data panel or to the main rack.

11. SWITCH AND DATA PANEL (fig. 10).

The switch and data panel is mounted at the front of the trailer and is accessible by means of a hinged door at the front (fig. 10). The panel contains receptacles for connecting the power-supply cable, the cables to the gun director, and terminals for the telephone lines. Switches that control the distribution of power and control the action of the blowers, heaters, and dehydrator are also located on the panel.

12. LIST OF MAJOR COMPONENTS.

A list of the major components of Radio Set SCR-784 is given in table I. This table includes every chassis and component considered to be a major unit. Photographs and drawings of components are inserted in the text where the component is discussed.

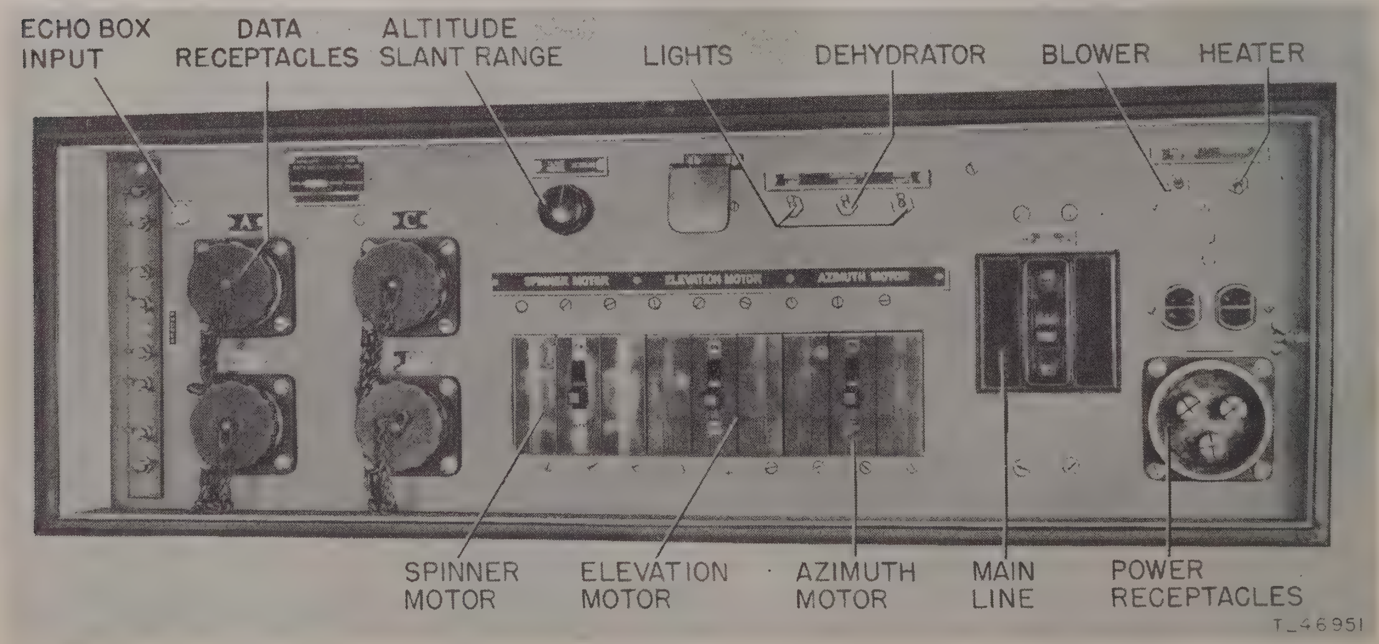


Figure 10. Switch and data panel.

TABLE I

LIST OF MAJOR COMPONENTS

Name of component	Signal Corps designation
Altitude converter power supply	Rectifier RA-70-A
Altitude converter	Control Unit BC-1094-C
Altitude data unit	Data Unit BC-1075-A
Antenna	Antenna AN-101-A
Antenna mount	Antenna Mount MP-61-B
Antenna position control unit	Control Unit BC-1085-C
Antenna position indicator unit	Indicator BC-1076-A
Automatic tracking unit	Tracking Unit BC-1086-C
Automatic range tracking unit	Range-Tracking Unit BC-1372
Automatic range tracking unit power supply	Power-Supply Unit RA-132
Azimuth and elevation tracking unit	Tracking Unit BC-1090-C
Crystal mixer	Crystal Mixer BC-1130-A
Driver unit	Driver Unit BC-1080-C
Field rectifier	Rectifier RA-71-A
Indicator-control panel	Indicator-Control Unit BC-1370
Line voltage regulator	Line-Voltage Regulator TF-14
Local oscillator	Oscillator BC-1374
Plan position indicator (PPI)	Indicator BC-1092-C
Plan position power supply	Rectifier RA-69-A
PPI unit	Plan-Position Unit BC-1058-C
Preamplifier	Amplifier BC-1078-A
Range indicator unit	Indicator BC-1371
Range power unit	Rectifier RA-72-A
Range unit	Range Unit BC-1062-C
Receiver	Receiver BC-1056-C
Receiver power supply	Rectifier RA-66-A
Remote video amplifier	Amplifier BC-1074-A
Servo motor-generator	
Switch and data panel	Data-Switch Panel PN-48
T-R box	Antenna Switch Box BC-1132-A
Trailer	Trailer K-84
Transmitter frame assembly	Transmitter Frame Assembly BC-1373

13. WEIGHTS AND DIMENSIONS OF COMPONENTS.

Weights in pounds and dimensions in inches of the major components of Radio Set SCR-784 are given in table II.

TABLE II

WEIGHTS AND DIMENSIONS OF MAJOR COMPONENTS

Component	Width (in.)	Depth (in.)	Height (in.)	Weight (lb)
MAIN RACK				
Range unit	19	13⅛	8¾	26
Range indicator unit	19	14	26¼	254
Receiver	19	13⅛	8¾	30
PPI unit	19	13⅛	8¾	34
Indicator-control panel	19	14	17½	51
Automatic tracking unit	19	13⅛	8¾	45
Azimuth and elevation tracking unit	19	13⅞	8⅝	36
Antenna position indicator unit	19	14	8 11/16	73½
Antenna position control unit	19	13⅛	8 11/16	120
Rack	62¼	14	41½	253
LEFT RACK				
Altitude converter	19	14	8¾	49
Altitude converter power supply	19	14	8¾	65
Automatic range tracking unit	19	13⅛	8¾	35
Field rectifier	19	13⅛	8¾	35
Rack	19 3/16	17¼	44	80
RIGHT RACK				
Receiver power supply	19	13	8¾	64
Automatic range tracking unit power supply	19	13⅛	8¾	64
Range power unit	19	13⅛	8¾	67
Plan position power supply	19	13⅛	8¾	79
Rack	19 3/16	17¼	44	80
TRAILER MOUNTED UNITS				
Transmitter frame assembly	56	30	29	863
Local oscillator	19	13⅛	8¾	43½
Driver unit	20¾	14⅛	12¼	64
Servo motor-generator	29 5/16	8	11½	132
Altitude data unit	10¾	11½	11½	40
Dehydrator unit	17¼	15 21/32	16⅞	100
Switch and data panel	39¼	6½	31	75
Blower motor	11½	11	14	42
Line voltage regulator	18	14	22	192

SECTION III

GENERAL FUNCTIONING

14. GENERAL.

Radio Set SCR-784 contains the necessary components and circuit refinements not only to present exact information on the location of targets, but also to use this information to control the set in tracking the target. This tracking action is entirely automatic. Voltages developed by the signal echo control the position of the antenna in azimuth and in elevation, and, if desired, enable the set to follow the target in range. A simplified functional block diagram of the set is shown in figure 11 and is explained in this section.

15. TRANSMITTING SYSTEM.

Any unique features of the transmitting system of the SCR-784 stem from the need to generate r-f pulses of very narrow width, high power, and high frequency. Once every 586 microseconds the system takes a pulse from the range unit, shapes this pulse (giving it the required form, width, polarity, and amplitude), and uses it to apply a d-c voltage of 22 kv for 0.8 microsecond to the transmitting tube. The transmitting system consists of a driver unit which shapes the pulses and triggers the modulator; a modulator which acts as an electronic switch to turn the high d-c voltage on and off; a high-voltage rectifier which produces the d-c voltage from a 115-volt, 60-cycle supply; and a magnetron which oscillates to produce the radio-frequency energy.

16. RADIO-FREQUENCY SYSTEM.

The radio-frequency system consists of the r-f transmission line, T-R box, antenna, reflector, and all auxiliary elements which are involved in the conduction, radiation, and interception

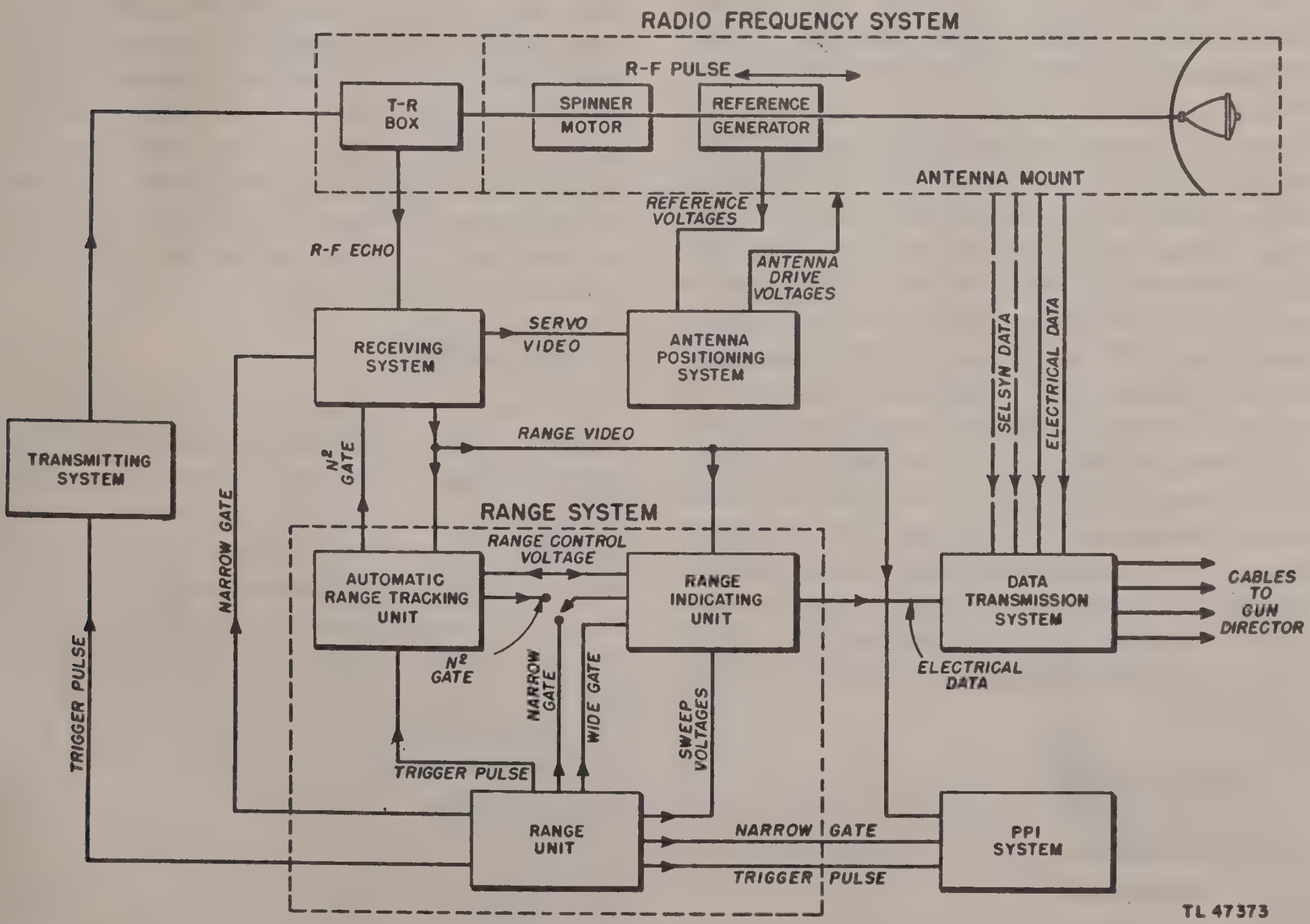


Figure 11. Functional block diagram of Radio Set SCR-784.

of r-f pulses. The r-f output of the magnetron in the transmitting system is fed into a coaxial r-f transmission line which conducts this r-f energy by a T-R box. After passing the T-R box, the energy is conducted to the antenna where it is radiated into space. The reflector behind the antenna gives this radiated energy its directional property by concentrating it into a narrow beam. Since the same antenna is used for both transmitting and receiving, the T-R box is necessary to prevent the energy from the transmitted pulse from entering and damaging the receiver. The transmission line has two slow moving rotating joints which allow the antenna to move in azimuth and elevation. The antenna and the generator furnishing the reference voltages used in automatic tracking are coupled directly to the spinner motor and rotate together in order to obtain the error signal arising from conical scanning. These two reference voltages were discussed in paragraph 3 **a.**

17. RECEIVING SYSTEM.

The receiving system of Radio Set SCR-784 amplifies and detects the target echoes received by the antenna. The system consists of the mixer, local oscillator, preamplifier, receiver, and remote video amplifier. The echo signal from the target is received by the antenna and conducted through the r-f system to the receiver, where it is mixed with a signal from the local oscillator. The result of this mixture is amplified in the i-f section of the receiver. The i-f signal then divides and goes through the range and servo channels of the receiver. The signal is amplified in the range channel, then fed to the range and PPI scopes and to the automatic range tracking unit. The servo channel is strobed by either the narrow-gate pulse from the range unit or the N^2 gate from the automatic range tracking unit so that the servo channel is opened up only long enough to receive the echo from a particular target being followed. The echo is amplified and its corresponding error voltage arising from conical scanning is passed on to the antenna positioning system to position the antenna.

18. RANGE SYSTEM.

The range system consists of the range unit, the range indicator unit, and the automatic range tracking unit.

a. Range Unit. The range unit generates all the trigger pulses and timebases for the various units. At the same time that the transmitter is triggered, the timebases on the range indicator unit start and are unblanked.

b. Range Indicator Unit. The range indicator unit consists of the two range scopes, the TRACKING and SLEWING handwheels, the aided-tracking mechanism, the range motor servo system, and the phase-shifting oscillator circuit for the automatic range unit. The range scopes have circular sweeps which are generated in the range unit and all the targets within the r-f beam are displayed on the 32,000-yard scope. The 2,000-yard scope expands any 2,000-yard portion of the 32,000-yard scope for greater tracking accuracy. The same narrow gate or the same N^2 gate that strobes the servo channel in the receiver also appears on the range scopes so that the operator knows which target the antenna is tracking.

c. Automatic Range Tracking Unit (ART). The automatic range tracking unit generates the N^2 gate and supplies the control voltages necessary to keep the hairlines of the range scope aligned perfectly with respect to the N^2 gate and the target being followed. The timing circuits in the ART unit are triggered by the same pulse which triggers the transmitter so that target echoes appear at the same point on all the timing circuits. The position of the target echo in relation to the position of the N^2 gate determines the direction and magnitude of the control voltages which drive the range hairlines on the range scopes and cause the hairlines to follow the target.

19. PPI SYSTEM.

The primary function of the PPI system is to locate targets during the searching operation. All the targets within the r-f beam, as well as the narrow gate and the range-marker circles, are displayed on the PPI scope. Thus the PPI scope furnishes information enabling positioning of the tracking hairline of the range scope by the proper adjustment of the handwheels to get the target in the tracking gate. During automatic tracking the PPI scope enables other targets to be spotted with respect to the target being tracked. The timebase is triggered by a pulse from the range unit, enabling the PPI scope to give a range indication. The timebase rotates with the antenna in azimuth, enabling the PPI scope to indicate the azimuth direction in which the antenna is pointed.

20. ANTENNA POSITIONING SYSTEM.

The antenna positioning system includes the antenna positioning controls, the automatic tracking unit, the azimuth and elevation tracking unit, the azimuth and elevation servo units, and the antenna drive motors. The error voltage is combined with the reference voltages, thus producing the desired control voltages for the antenna drive motors. When positioning the antenna manually, "artificial" error signals for the antenna position control unit and one reference voltage is combined to produce the same result. A single group of circuits serves for all methods of antenna control, with the difference in the circuits' operation depending on the nature and source of the error and reference voltage.

21. DATA TRANSMISSION SYSTEM.

The data transmission system includes: the antenna position indicator; the azimuth, range, and elevation potentiometers; the selsyns; the altitude data unit; and the altitude converter power supply. The selsyns (coarse and fine), which transmit azimuth and elevation angles; and the potentiometers, which transmit range, azimuth, elevation angle, and altitude; respond instantly to all changes in target position. The transmission of data may be electrical (by use of control voltages developed across the potentiometers) or mechanical (by means of the selsyns). The accuracy of the data supplied to the gun director depends primarily on the accuracy with which Radio Set SCR-784 tracks the targets.

CHAPTER 2
TRANSMITTING SYSTEM

SECTION I
INTRODUCTION

22. SIMPLIFIED BLOCK DIAGRAM (fig. 12).

The transmitting system consists of the driver unit which is housed in the transmitter frame assembly but is a separate unit; the transmitter frame assembly (fig. 8) containing the modulator, high-voltage rectifier, and magnetron; and part of the indicator-control panel. They are functionally related as shown in the simplified block diagram. The driver unit receives 15-volt negative pulses from the range unit at the rate of 1,707 pulses per second and delivers positive 3.5-kv output pulses (at the rate of 1,707 pulses per second) to the modulator in the transmitter frame assembly. The modulator amplifies each 3.5-kv pulse to 22 kv and applies it to the magnetron. This turns the magnetron on and off 1,707 times per second. The high-voltage rectifier supplies the d-c energy which the magnetron converts to r-f energy. This r-f energy is fed to the antenna through the r-f system. Controls for varying the power output of the set and checking the operation of the transmitting system are located on the indicator-control panel in the main rack (fig. 6).

23. COMPLETE BLOCK DIAGRAM (fig. 13).

a. Driver Unit. The driver unit is triggered by the 15-volt negative pulse from the range unit and produces a positive 3,500-volt pulse in its driver stages. The principal waveforms are shown in time phase in figure 14.

(*1*) *Multivibrator.* The 15-volt negative trigger pulse is fed to the multivibrator V101 to obtain a narrow rectangular negative pulse suitable for controlling the driver stages.

(*2*) *Inverter.* The negative output of the multivibrator is fed to the inverter V102, where it is amplified and inverted. The narrow rectangular pulse is now the proper shape and polarity and of sufficient amplitude to trigger the first driver.

(*3*) *First Driver.* The output of the inverter stage is fed to the first driver V103 where it is further amplified. The first driver produces a negative pulse output which is transformer coupled to the final driver stage. Thus the input pulse to the final driver is a positive pulse.

(*4*) *Final Driver.* The final driver stage V104 and V105 further amplifies the positive narrow pulse and produces across the secondary of its output transformer a 3,500-volt positive pulse with a fixed width of 0.8 microsecond.

(*5*) *Delay Line.* The delay line is an artificial transmission line which fixes the width of the driver unit output pulse at 0.8 microsecond.

b. Transmitter Frame Assembly. The components discussed below in the transmitter frame assembly take the 3,500-volt positive pulse produced in the driver unit and use it to produce an r-f pulse whose frequency is approximately 3,000 megacycles and whose peak power is about 250 kw.

(*1*) *Keyer Tubes.* The keyer tubes V203 and V204 are high-power transmitting tubes whose grid input is the 3,500-volt positive keying pulse from the driver unit. When this keying pulse is applied to the grids of the keyer tubes,

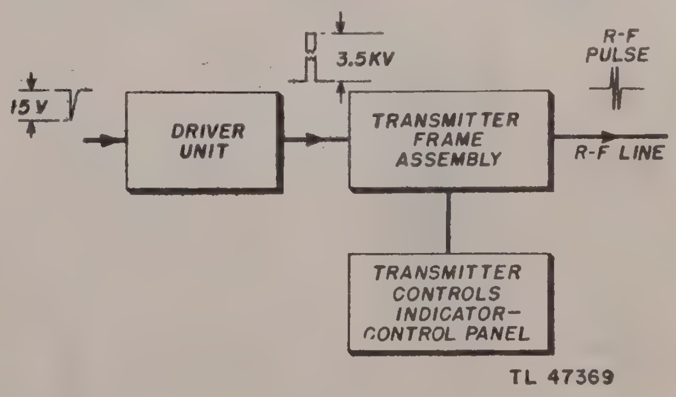


Figure 12. Transmitting system, simplified block diagram.

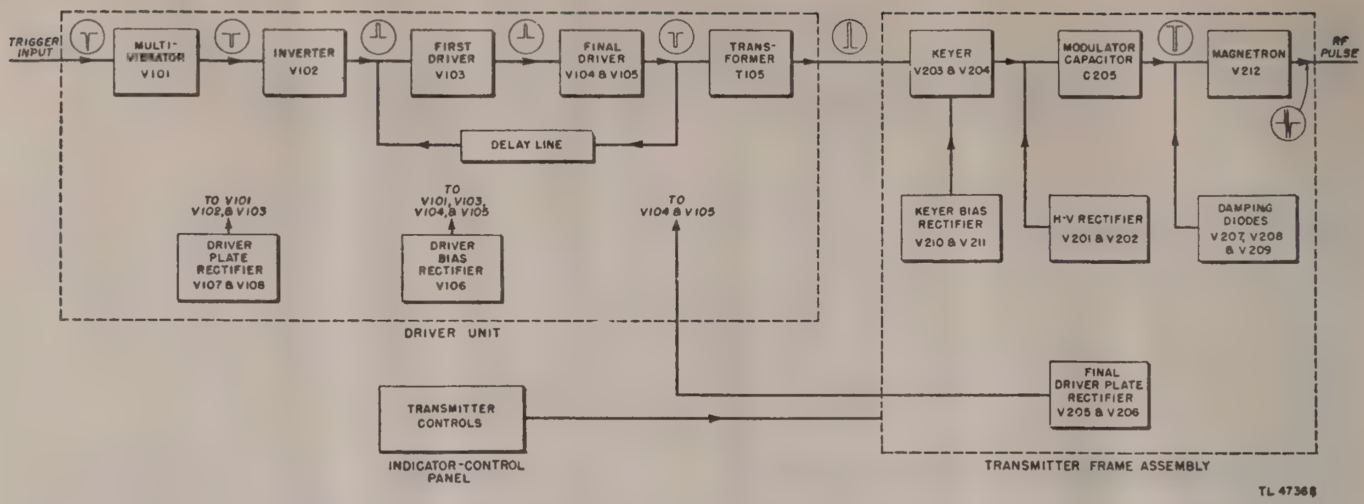


Figure 13. Transmitting system, complete block diagram.

they conduct and discharge the modulator capacitor through the magnetron, causing the magnetron to conduct.

(2) *Modulator Capacitor.* The modulator capacitor C205 is a large capacitor which is continuously charged from the high-voltage rectifier. The circuit is so arranged that the capacitor will discharge through the magnetron only when the positive keying pulse is applied to the grids of the keyer tubes.

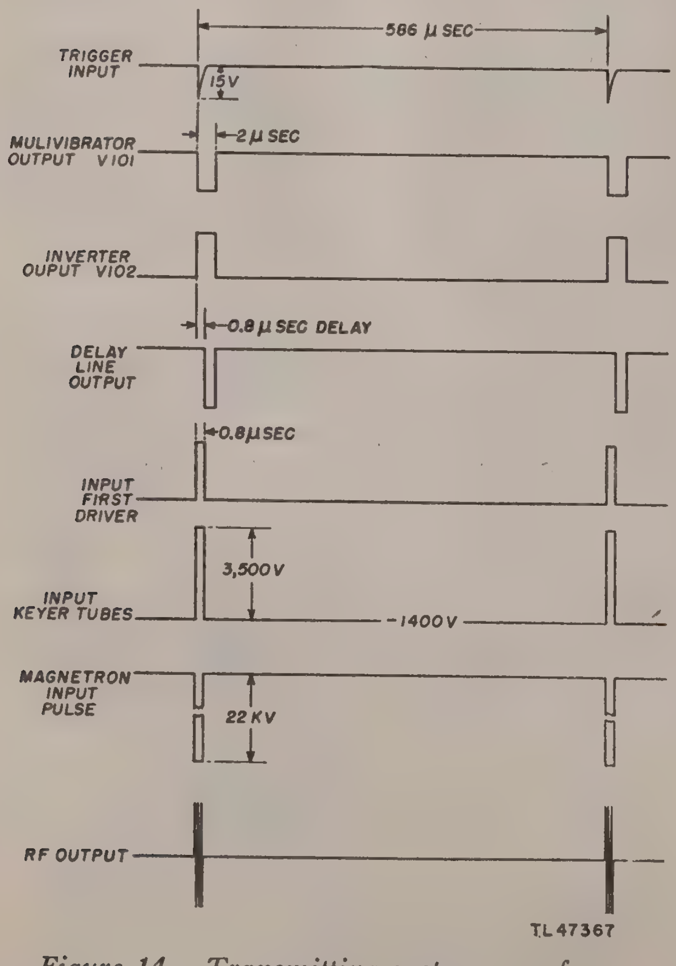


Figure 14. Transmitting system, waveforms.

(3) *High-voltage Rectifier.* The high voltage required by the magnetron is developed by a conventional voltage-doubler rectifier V201 and V202.

(4) *Damping Diodes.* The damping diodes V207, V208, and V209 are used to prevent the magnetron oscillations from continuing after the keying pulse has been removed.

(5) *Magnetron.* The magnetron converts the high-voltage d-c pulse applied to its cathode to the r-f energy which is radiated from the antenna.

(6) *Additional Rectifiers.* Other rectifiers to supply plate and bias voltages to the various stages are shown in the block diagram (fig. 13).

24. CABLING.

The cabling of the various components in the transmitter system is shown in figure 15. A-c power for the entire transmitting system is furnished from the switch and data panel through cable No. 21 and jack J208. This a-c

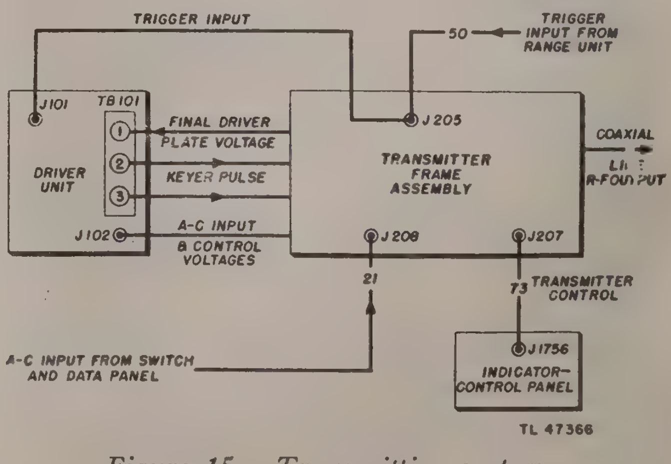


Figure 15. Transmitting system, cabling diagram.

power is applied to the various components in the transmitter frame assembly and also is applied to the driver unit through an internal cable whose plug P102 connects to jack J102 in the driver unit. The final driver stage is supplied d-c voltage and keyer pulse voltage through terminal board TB101. The trigger input from the range unit is supplied through cable No. 50 to jack J205 in the transmitter frame assembly, and then to jack J101 in the driver unit. Transmitter control cable No. 73 is connected between jacks J207 in the transmitter frame assembly and J1756 on the indicator-control panel.

SECTION II

DRIVER UNIT BC-1080-C

25. INTRODUCTION.

The driver unit (fig. 8) is mounted on a removable chassis located in the transmitter frame assembly. Figure 16 is a top view of the chassis showing the location of components, and figure 28 is a complete schematic of the driver unit. Simplified schematics explaining the action of the driver unit circuits are referred to in the circuit discussions in this section.

26. MULTIVIBRATOR V101 AND INVERTER V102 (fig. 17).

a. The multivibrator V101 is a conventional one-shot multivibrator, triggered by the negative 15-volt pulse from the range unit. Without this trigger pulse the transmitting system will not operate. The trigger pulse controls the operation of the multivibrator, which in turn controls the action of the following stages. The output of the multivibrator is a negative-going pulse of approximately 2 microseconds duration.

(*1*) In the absence of the trigger pulse, V101A is cut off due to the negative 18.5-volt bias on its grid and V101B is conducting heavily since its grid is at the same potential as its cathode. When the negative 15-volt trigger pulse is applied to the grid of V101B it is driven to cut-off causing the voltage at its plate to rise. This voltage rise is coupled to the grid of V101A through capacitor C103 and overcomes the negative 18.5-volt bias on the grid of V101A causing V101A to conduct. When V101A conducts, its plate voltage drops. The drop in plate voltage at V101A is coupled back to the grid of V101B driving V101B further beyond cut-off and keeping it cut off after the trigger pulse has passed. Section V101B is now cut off and section V101A is conducting heavily. Capacitor C102 was originally charged to the difference in potential between the plate of V101A and ground. The drop in plate voltage at the plate of V101A causes the side of capacitor C102 con-

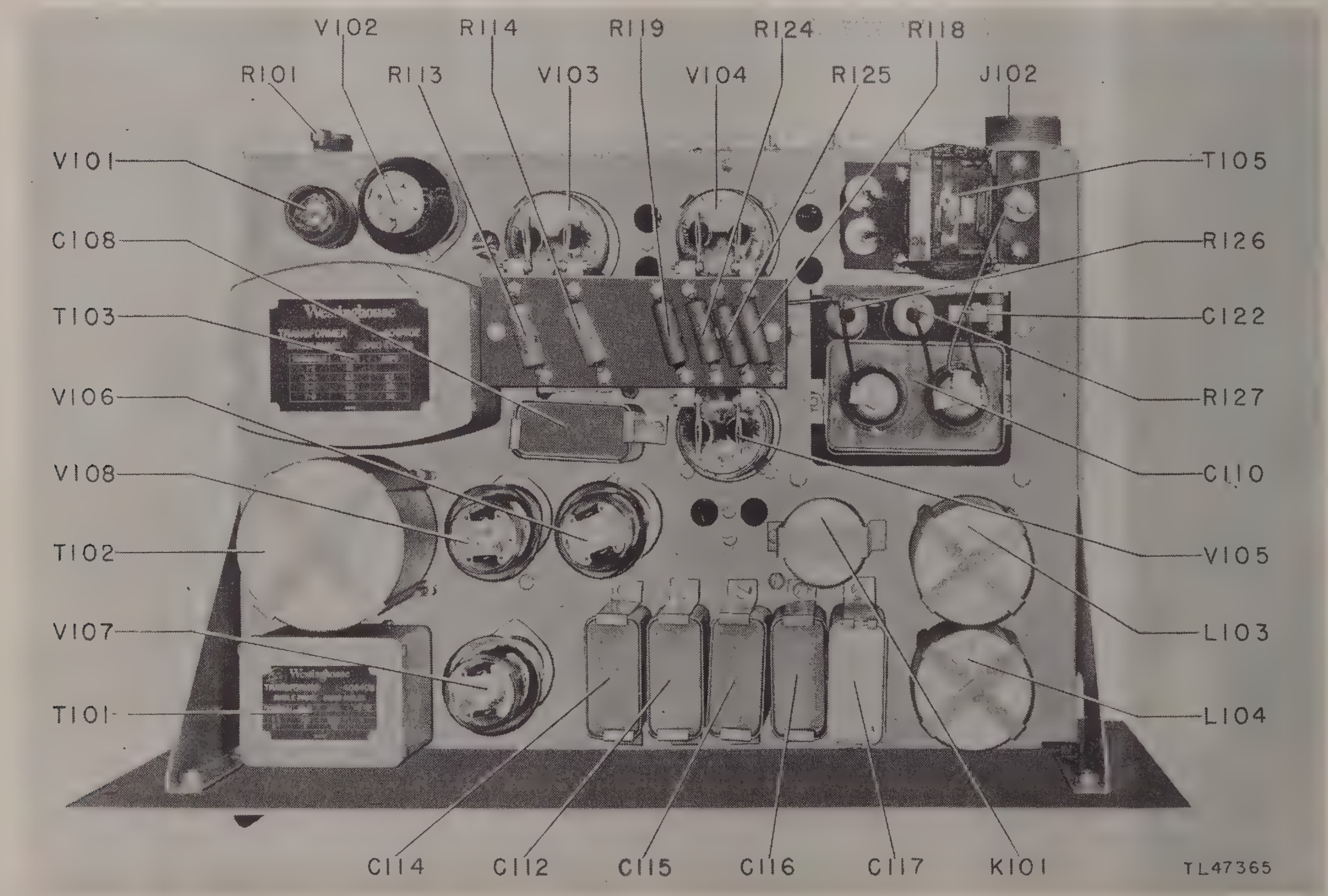


Figure 16. Driver unit, top view.

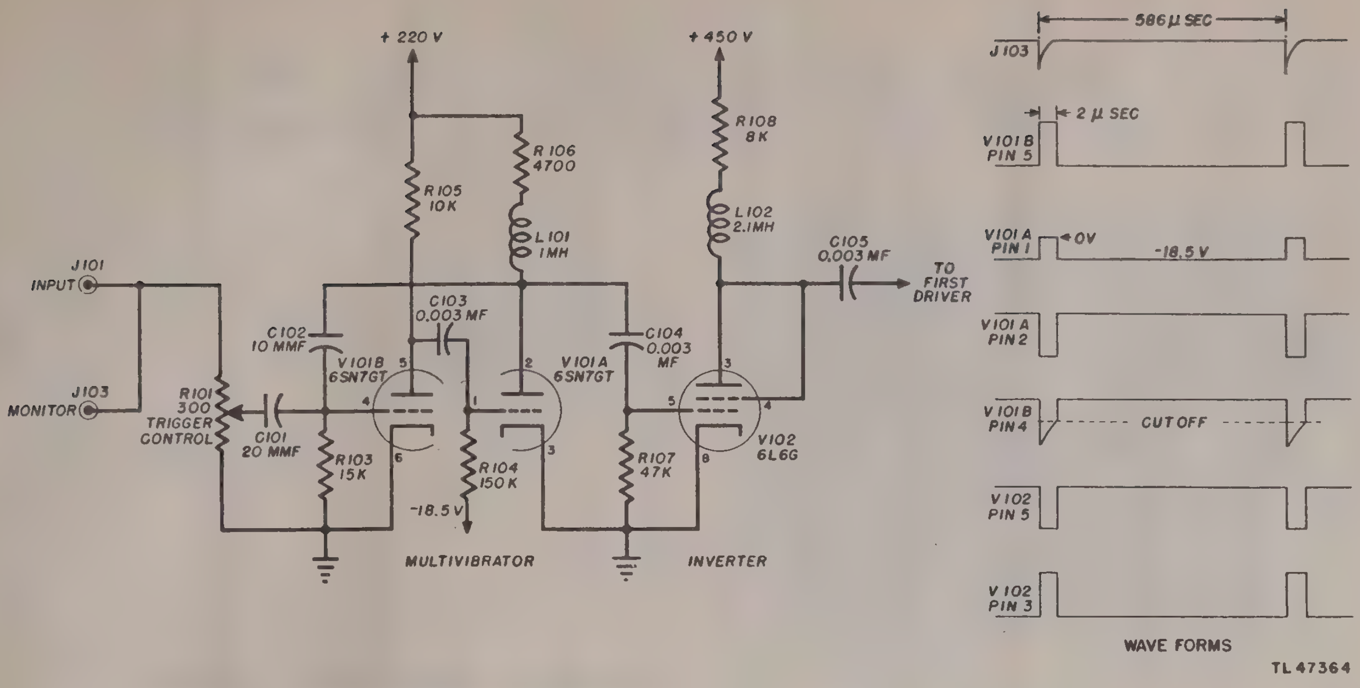


Figure 17. Driver multivibrator and inverter.

nected to the grid of V101B to go negative with respect to ground. Capacitor C102 now begins to discharge through R103 and through R106 and the power supply. As soon as it has discharged sufficiently to allow the grid potential of V101B to rise above cut-off, V101B again conducts, driving the stage to its original condition before the trigger pulse was applied. The length of time V101B remains cut off (approximately 2 microseconds) is determined by the time constant of the discharge circuit of capacitor C102.

(*2*) Potentiometer R101, trigger control, controls the amplitude of the input pulse. The base of the trigger pulse may be wider than 2 microseconds, in which case it would hold V101B cut off for the width of the pulse. Decreasing the amplitude of the pulse reduces the width of the base so that the trigger pulse will not affect the duration of the output pulse and the time constant of the discharge circuit of capacitor C102 remains the controlling factor in the duration of the output pulse of the multivibrator.

(*3*) Coil L101 in the plate circuit of V101A serves to sharpen the output pulse. As soon as V101A conducts and current flows through L101, a voltage is developed across L101 whose polarity is in such a direction as to aid the electron flow. Since the electrons flow from the plate of V101A to the B+ supply, the voltage developed across L101 is in the same direction as the voltage drop across resistor R106. This produces a sharp corner to the negative voltage pulse output. The same action takes place as V101A is cut off, squaring the two corners of the 2-microsecond output pulse.

b. The negative output of the multivibrator is coupled to the grid of inverter V102 through capacitor C104. In the absence of this pulse from the multivibrator, the inverter conducts heavily. When the negative pulse is applied to its grid, the inverter is driven to cut-off, resulting in a positive pulse at the plate of the inverter. Coil L102 is added in the plate circuit of V102 to again sharpen the output pulse and acts in the same manner as described in subparagraph **a** (*3*) above. Inverter V102 is also an amplifier, so that, while being inverted, the pulse is amplified.

27. DRIVER STAGES (fig. 18).

a. The driver stages further amplify the pulse to sufficient amplitude to operate the keyer tubes in the modulator. In order to reduce the internal impedance of the tubes, thus giving larger outputs, the tubes used in the driver stages are 3E29 dual-type tubes. This gives, in effect, two tubes in parallel for the first driver V103 and four tubes in parallel for the final driver stage V104 and V105. In the absence of

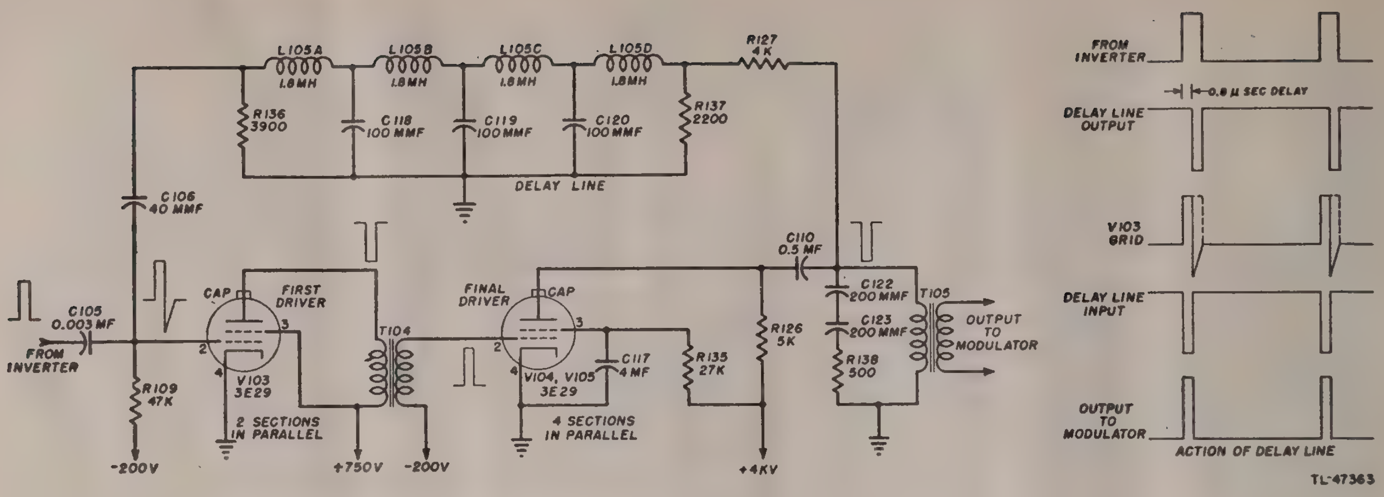


Figure 18. Driver stages.

a pulse from the inverter, both driver stages are cut off by their 200-volt negative bias.

b. The first driver stage begins to conduct as soon as the positive pulse from the inverter stage is applied to its control grid. Its negative pulse output is inverted in transformer T104 and applied to the grid of the final driver stage as a positive pulse. The final driver stage then conducts heavily and its resulting negative pulse output is applied to the delay line and to output transformer T105.

c. Because of the characteristics of the delay line, this negative pulse appears at capacitor C106 0.8 microsecond after it is applied to the output transformer T105. The delay in such a transmission line can be visualized by considering capacitor C119 charging from capacitor C120 through the connecting impedance and capacitor C118 charging from C119 in the same manner. This action continues until the end of the delay line is reached. This negative pulse from the delay line is sufficient to cut off the first driver stage (even though the positive pulse from the inverter is still being applied to its grid) thus narrowing the pulse down to 0.8 microsecond duration.

d. Transformers T104 and T105 are special pulse transformers designed to pass the high-frequency components in the narrow pulse. The output of transformer T105 is a 3,500-volt positive pulse. Capacitors C122 and C123 and resistor R138 are added to the primary circuit of T105 to preserve the desired waveform and prevent any undesired oscillation due to the stray capacitance and inductance of the transformer.

28. DRIVER POWER SUPPLIES (fig.19).

The power supplies in the driver unit are conventional full-wave rectifiers. Rectifier V106 supplies the negative 200-volt bias for the driver stages and the negative 18.5-volt bias for the multivibrator. The rectified current that flows through the bleeder resistors also flows through the coil of the protective relay K101. The contacts of K101 close only when the output of the bias supply reaches a predetermined value, thus preventing the high voltage from being applied to the driver tubes without any bias and burning out the tubes. Rectifiers V107 and V108 are in series with voltage taps to the various stages of the driver unit. Plate voltage for the final driver stage is furnished by a rectifier in the transmitter frame assembly.

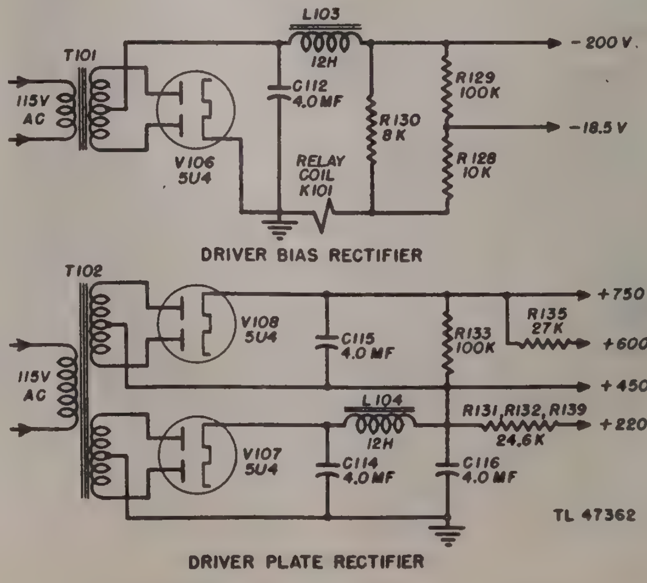


Figure 19. Driver power supplies.

SECTION III

TRANSMITTER FRAME ASSEMBLY BC-1373

29. INTRODUCTION.

The transmitter frame assembly contains the necessary high-voltage circuits (fig. 29) for the proper operation of the magnetron oscillator. The location of the various components is shown in figure 20 and they are discussed in this section. All of the operating controls (fig. 21) are brought out to the indicator-control panel. Figure 30 is a complete schematic diagram of the indicator-control panel.

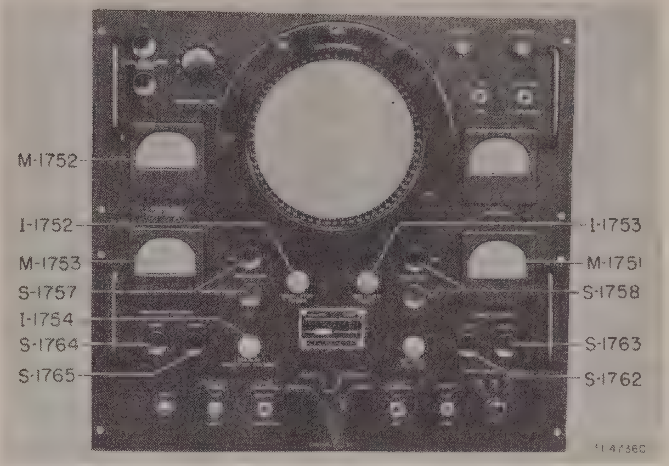


Figure 21. Indicator-control panel.

30. MODULATOR AND MAGNETRON (fig. 22).

a. Modulator Circuit.

(*1*) The modulator capacitor C205 is in series with the magnetron across the 22-kv power supply. Keyer tubes V203 and V204 are connected across the 22-kv power supply and are normally cut off by the negative 1,400-volt bias on their grids. With the keyer tubes cut off, modulator capacitor C205 is charged to plus 22 kv through coils L204 and L202, resistor R212, and the magnetron current meter M1752 (fig. 22B). When the 3,500-volt positive pulse is applied to the grids of the keyer tubes, they conduct and furnish a path for the modulator capacitor to discharge. This puts a 21- to 22-kv negative pulse on the cathode of the magnetron (fig. 22C) which causes the magnetron to oscillate. Because of the large capacitance of the modulator capacitor and the short

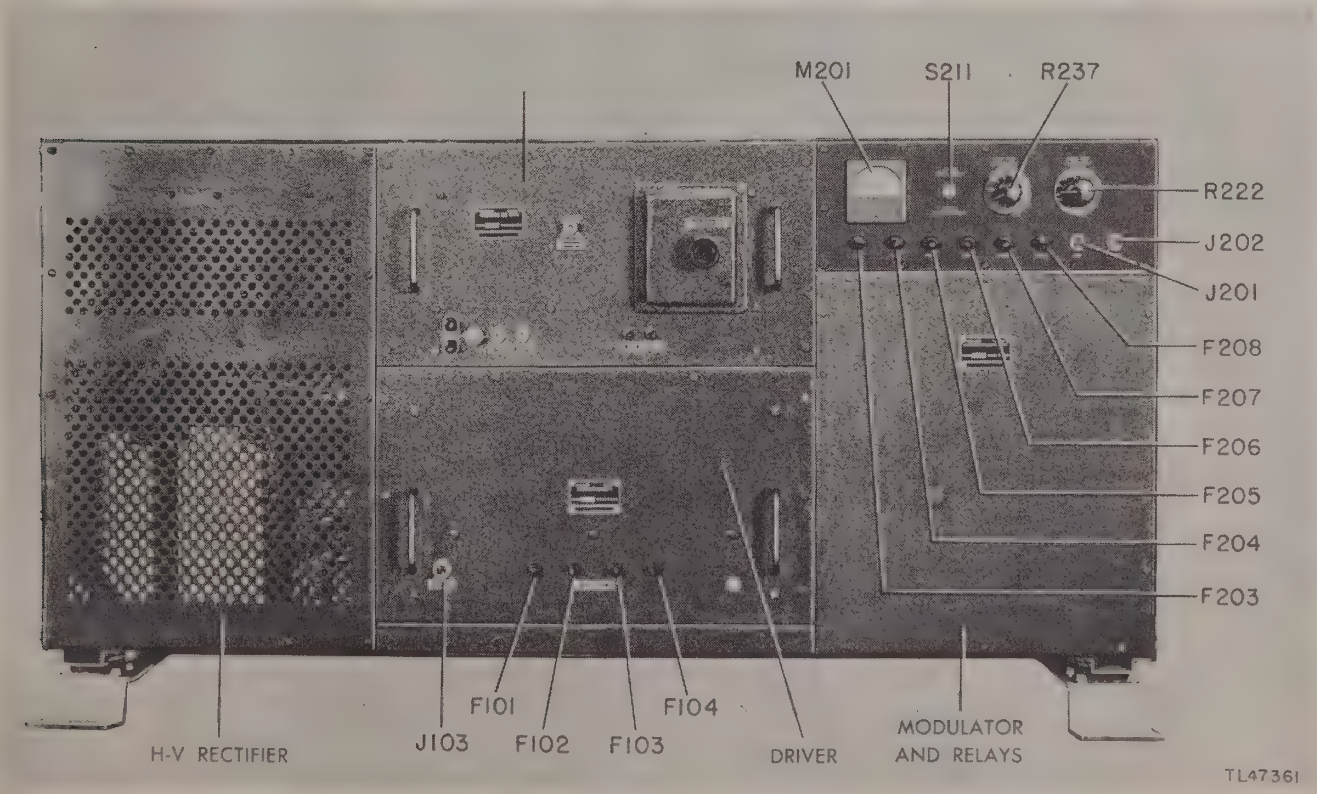


Figure 20. Transmitter frame assembly, front view.

interval during which the capacitor is discharged through the magnetron, the voltage on the magnetron is maintained essentially constant for the 0.8 microsecond duration of the pulse. During the interval that the capacitor is discharging through the magnetron, resistor R212 and coil L204 prevents excessive current from being drawn from the high-voltage rectifier because of the high impedance offered by the coil to sudden changes in current. Coil L203 offers a very high impedance to the sudden rise in voltage caused by the positive pulse from the driver, thus helping to preserve the steep wave front. A strong magnetic field is built up around L203 during the pulse. When the positive pulse disappears, the magnetic field collapses and the resulting current charges the grid-cathode capacitance of the modulator tubes so as to drive the grids negative. This action is instantaneous, resulting in a steep wave front at the trailing edge of the pulse and causing the grids to go negative below the reference point represented by their stable condition before the positive pulse appears. Capacitor C204 effectively grounds L203 for the r-f frequency of the pulse.

(*2*) When the modulator capacitor discharges, all the energy is supplied to the magnetron because coil L202 offers a high impedance due to the rapid change of current. When the keyer tubes are cut off, the cathode of the magnetron rises to its normal ground potential. This is an exponential rise (fig. 23) due to the resistance in the circuit. Coil L202 will oscillate with its own stray capacitance and that of the magnetron, bringing the cathode potential of the magnetron up to ground potential quickly but causing oscillations to occur. These oscillations are prevented by the use of damping diodes V207, V208, and V209. As soon as the oscillation goes positive the diodes conduct, damping out the oscillations (fig. 23).

(*3*) Meter M1752 indicates the magnetron current. When the modulator capacitor is charging, this charging current flows through

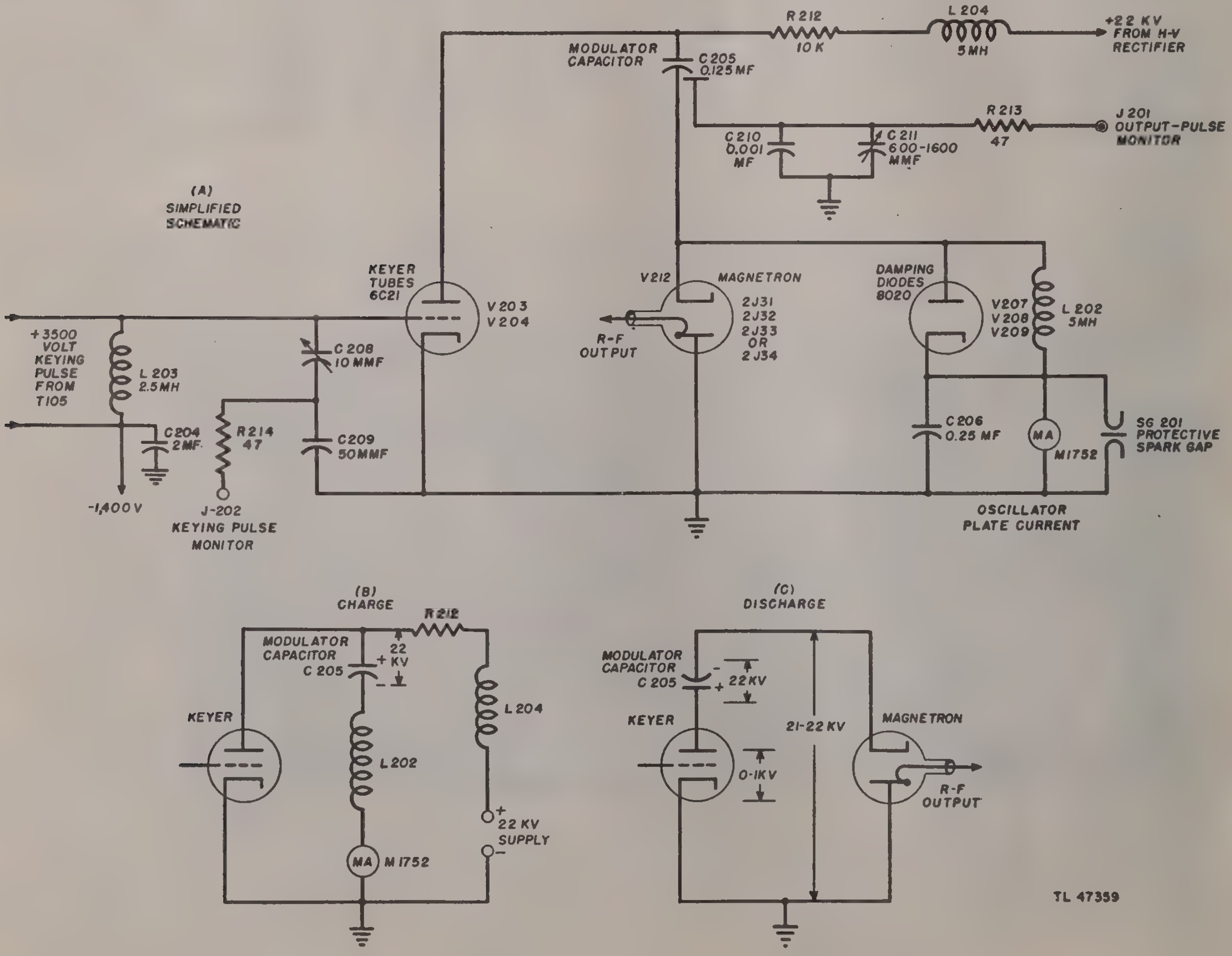


Figure 22. Modulator, simplified schematic diagram.

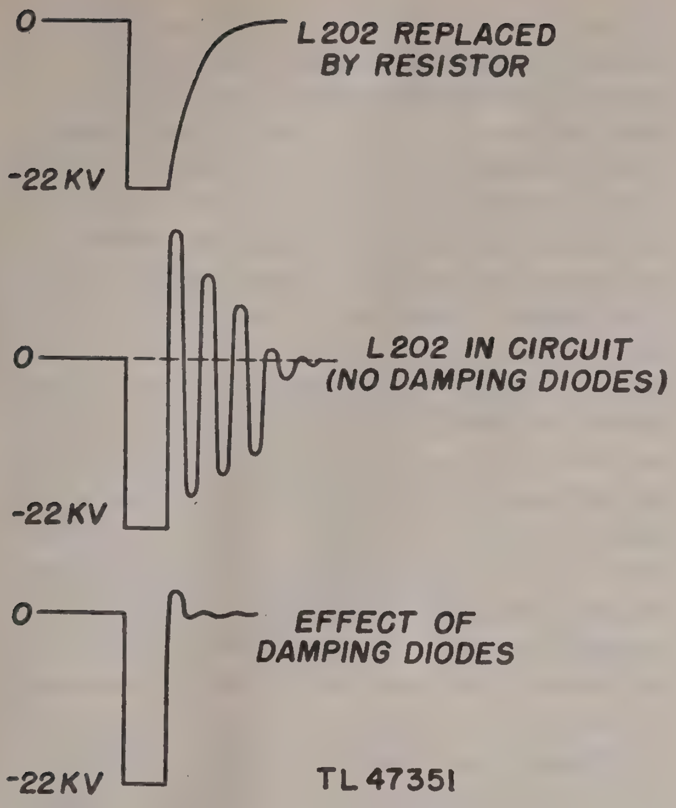


Figure 23. Pulse applied to the magnetron.

meter M1752. The same amount of energy that went into the modulator capacitor is discharged through the magnetron, so that although meter M1752 reads the capacitor charging current it is the same value as the magnetron plate current. Capacitor C206 smooths out the current flow through the meter, and spark gap SG201 protects the meter against excessive voltages.

(*4*) Monitoring jack J202 is provided to check the keying pulse applied to the grids of the keyer tubes, and jack J201 is provided to check the modulator-output pulse. Capacitive voltage dividers are set at the factory to limit the monitoring voltages to a safe value for application to the test scope.

b. Magnetron.

(*1*) The magnetron is mounted between the pole faces of a permanent magnet (fig. 24), the magnetic field of which is necessary for operation of the tube. The magnetron has its own built-in tuned circuit. When a voltage

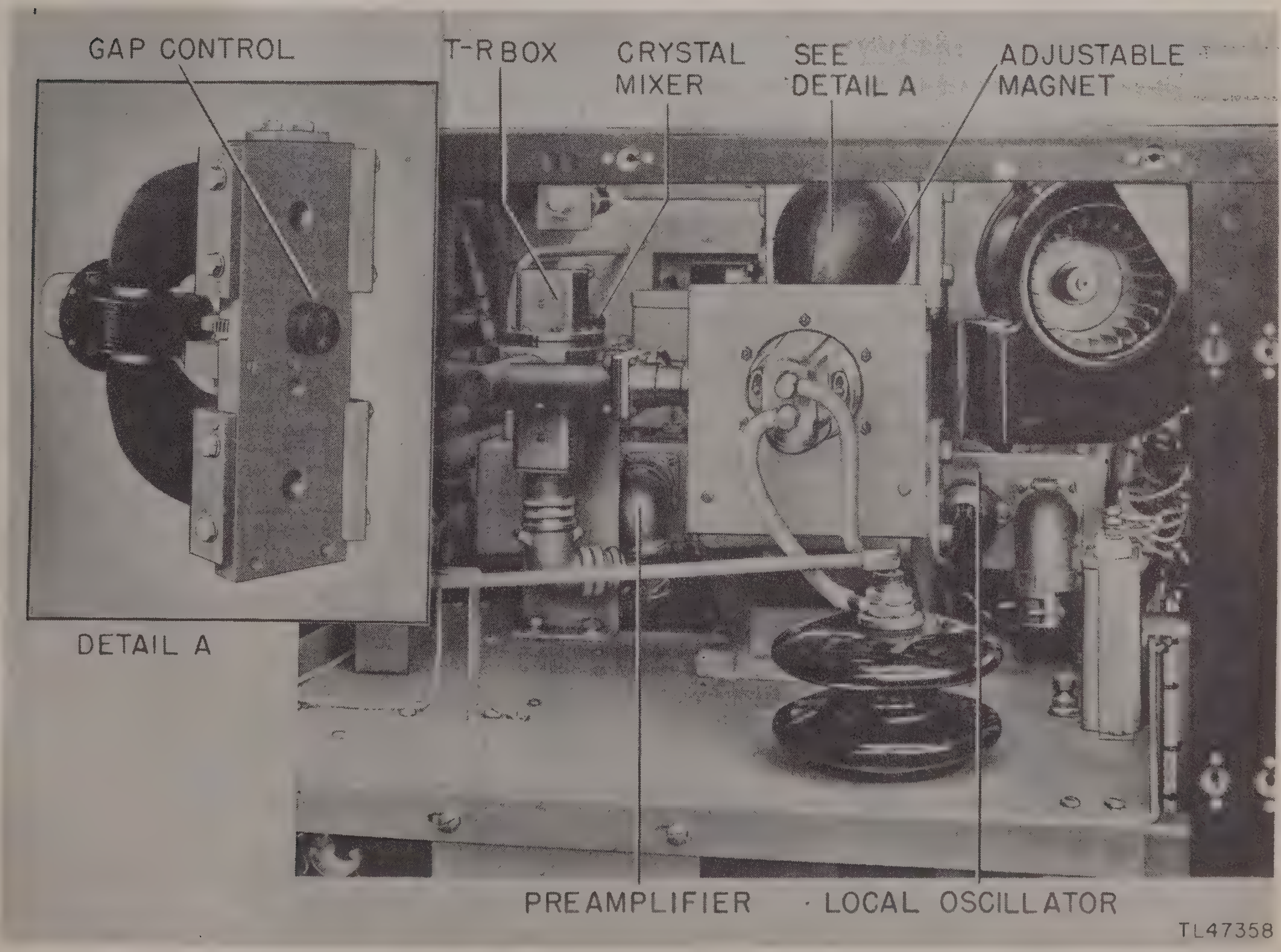


Figure 24. Magnetron mounting.

pulse of the proper magnitude (22 kv) and the correct magnetic field strength is applied, the magnetron will oscillate at a frequency determined by the internal construction of the tube. The strength of the magnetic field can be adjusted by varying the air gap between the pole faces to secure maximum efficiency. The high-voltage pulse is supplied to the magnetron through a high-voltage concentric bushing shown in figure 24.

(*2*) Although the frequency of the magnetron cannot be changed, it may go into oscillation at other frequencies, resulting in overheating and lower output. This is known as double moding and is usually due to a change in loading, a change in magnetic field strength, or a change in the applied voltage. It can be detected by the appearance of a smaller pulse which varies in amplitude underneath the main pulse on the 2,000-yard scope. Double moding may be overcome by changing either the strength of the magnetic field or the rectifier plate voltage, thus changing to an operating point at which the magnetron operation is more stable.

31. POWER SUPPLIES.

a. High-voltage Power Supply. The high-voltage power supply uses a conventional voltage-doubler rectifier. Its output is about 22-kv. The output voltage is varied by the motor-driven auto-transformer T201 which varies the input to transformer T202. Refer to figure 25. When the output voltage of transformer T202 is such that the plate of tube V202 is positive, capacitor C201 charges in the direction shown by the arrows to the value of the output voltage of transformer T202. This makes the upper plate of capacitor C201 positive with respect to the lower plate. On the negative half cycle the cathode of V201 is negative with respect to its plate; so it conducts, and capacitor C202 charges to the value of the output voltage of transformer T202. The voltage across capacitor C202 adds to the voltage across capacitor C201. The output voltage is therefore about twice the peak secondary voltage of transformer T202. Relay K206 short circuits the capacitors to ground through resistors R201 and R202 whenever the circuit is de-energized. Overload relay K203 operates to break the a-c supply circuit whenever the total current through the load exceeds 50 milliamperes. The overload point at which K203 operates is changed by varying resistor R222. With more resistance in parallel with the coil of K203, less total current is required to operate the relay. Meter M1753 is calibrated to measure the output of the high-voltage rectifier.

b. Driver Plate and Keyer Bias Power Supplies. The driver plate and keyer bias power supplies (fig. 26) use conventional full-wave rectifiers with very little filtering action.

(*1*) The driver plate rectifier V205 and V206 furnishes plus 4,000 volts to the plates of the final driver tubes through terminal board TB101. With switch S211 on contacts No. 3 and No. 6, meter M201 measures the output current of the driver plate power supply (fig. 29).

(*2*) The keyer bias rectifier V210 and V211 furnishes a negative 1,400-volt bias for the grids

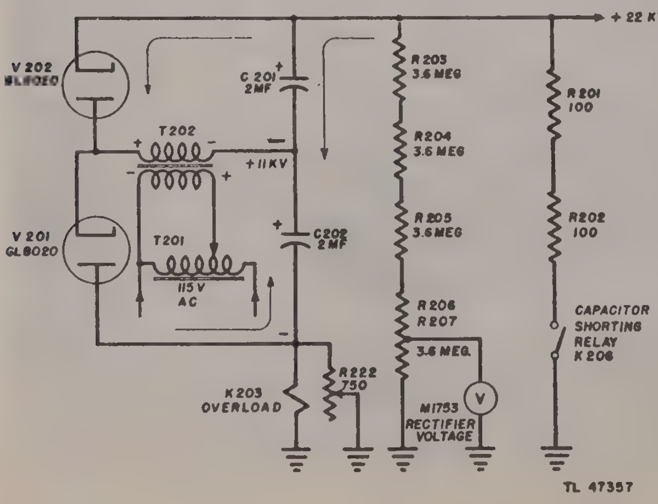


Figure 25. High-voltage power supply.

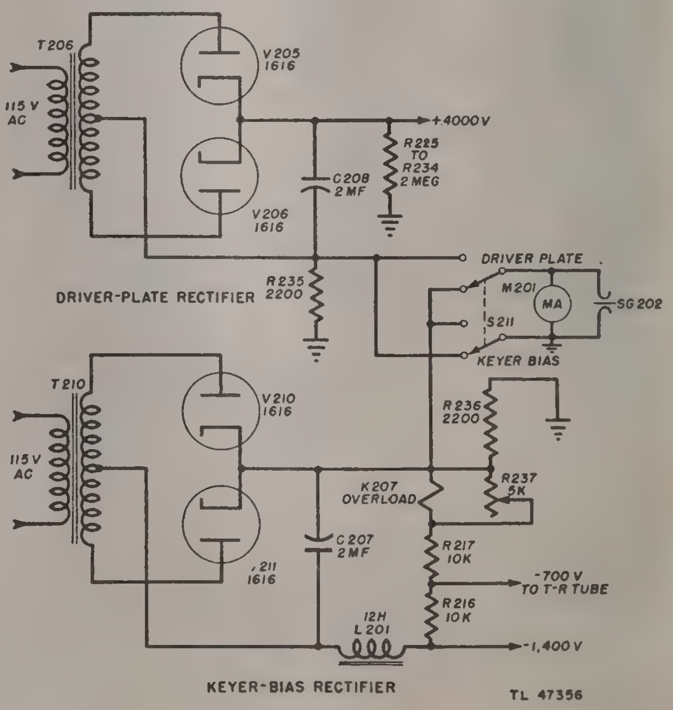


Figure 26. Driver plate and keyer bias power supplies.

of the keyer tubes. A negative 700-volt tap is taken off the bleeder resistors R217 and R216 to furnish keep-alive voltage to the T-R tube. Resistors R218, R219, R220, and R221 (fig. 29) limit the current to the T-R tube. The output current of the keyer bias power supply is measured on meter M201 when switch S211 is on contacts No. 2 and No. 5.

(*3*) Meter M201 is protected against excessive voltages by the protective spark gap SG202. Relay K207 is an overload relay which operates at 50 milliamperes and removes power from the high-voltage rectifiers. The overload value at which relay K207 operates is adjusted by means of resistor R237.

32. CONTROL CIRCUITS (fig. 27).

The operating controls for the transmitter frame assembly are located on the indicator-control panel in the main rack. Figure 30 is a complete schematic diagram of the indicator-control panel. The circuits are interlocked to prevent damage to the equipment and to safeguard personnel. Before starting the equipment, check to see that the input voltage at the indicator-control panel is 115 volts so that all voltages to the filaments of the tubes will be correct.

a. Three-phase power is brought into the transmitter frame assembly through jack J208 and circuit breaker K201. Only single-phase power is used in this unit; phase C on relay K201 is left disconnected.

b. When the modulator ON switch S1757 is depressed the coil of circuit breaker K201 is energized and line contact L_1 closes to T_1 and L_2 closes to T_2. Circuit breaker K201 is held closed, when the ON switch is released, by its holding contacts No. 1 and No. 2.

c. The following circuits are energized through fuses F201 and F202.

(*1*) MODULATOR POWER white pilot light I1752.

(*2*) Driver filaments and negative 200-volt driver bias power supply.

(*3*) Local oscillator power supply.

(*4*) High-voltage rectifier filament transformers T204 and T203.

(*5*) Keyer tubes filament transformer T207.

(*6*) Keyer tubes blower motors BL203 and BL202.

(*7*) Magnetron filament transformer T211.

(*8*) Magnetron blower motor BL201.

(*9*) Damping diodes filament transformer T208.

(*10*) 4,000-volt driver plate power supply filament transformer T205.

(*11*) Keyer bias power supply filament transformer T209.

(*12*) Coil of bias time delay relay K205.

(*13*) MINIMUM RECTIFIER VOLTAGE amber pilot light I1754 (if switch S212 is closed).

d. The driver bias current relay K101 should operate and its contacts close a few seconds after the negative 200-volt driver bias power supply is energized (when the output voltage reaches 95 volts).

e. Thirty seconds after the bias time delay relay K205 is energized, its contacts No. 3 and No. 4 close.

f. If fuses F205 and F206 are good, relay K204 will be energized provided that: contacts on K205 are closed, contacts of the high-voltage overload relay K207 are closed, interlock switches S204 through S210 are closed, and relay K101 is energized and its contacts closed. This applies power to the high-voltage transformer T210 of the keyer bias power supply. At the same time the high-voltage shorting relay K206 will be energized, removing the short from across the high-voltage power supply (fig. 25.)

g. The rectifier should be adjusted so that its output is zero when it is turned on. This prevents the filter capacitors from drawing too great an initial charging current through the high-voltage rectifier tubes. When the rectifier is turned on under this condition, switch S212 will be closed and the yellow pilot lamp I1754 will be lit.

h. Depressing the high-voltage rectifier ON switch S1758 energizes relay K202. With the contacts of relays K202, K203, and K204 closed, power is applied to the high-voltage rectifier transformer. The holding contacts A and D of relay K202 keep the circuit energized after the rectifier ON button is released. The circuit is completed through contacts C and F of relay K204 to prevent the high-voltage rectifier from being energized without any bias on the keyer tubes. The high-voltage rectifier cannot be turned on before the modulator-power switch S1757 is closed because the circuit for the coil of relay K202 is completed through contacts No. 1 and No. 2 of relay K201.

i. The output voltage of the high-voltage rectifier is raised by operating control switch S1764. The RAISE and LOWER switches are

so arranged that depressing both of them at once will cause no trouble. As soon as the high-voltage rectifier output voltage rises above 10 kv, switch S201 closes and energizes the driver low-voltage power supply transformer T102 and the final driver plate power supply transformer T206. The magnetron r-f power output is increased or decreased by raising or lowering the output voltage of auto-transformer T201. Switches S201, S202, and S203 are mechanically ganged to the variable tap of the auto-transformer T201, so that when the output voltage is at its highest value switch S202 removes the RAISE switch from the circuit; and when the output voltage reaches its lowest value, switch S203 removes the LOWER switch from the circuit.

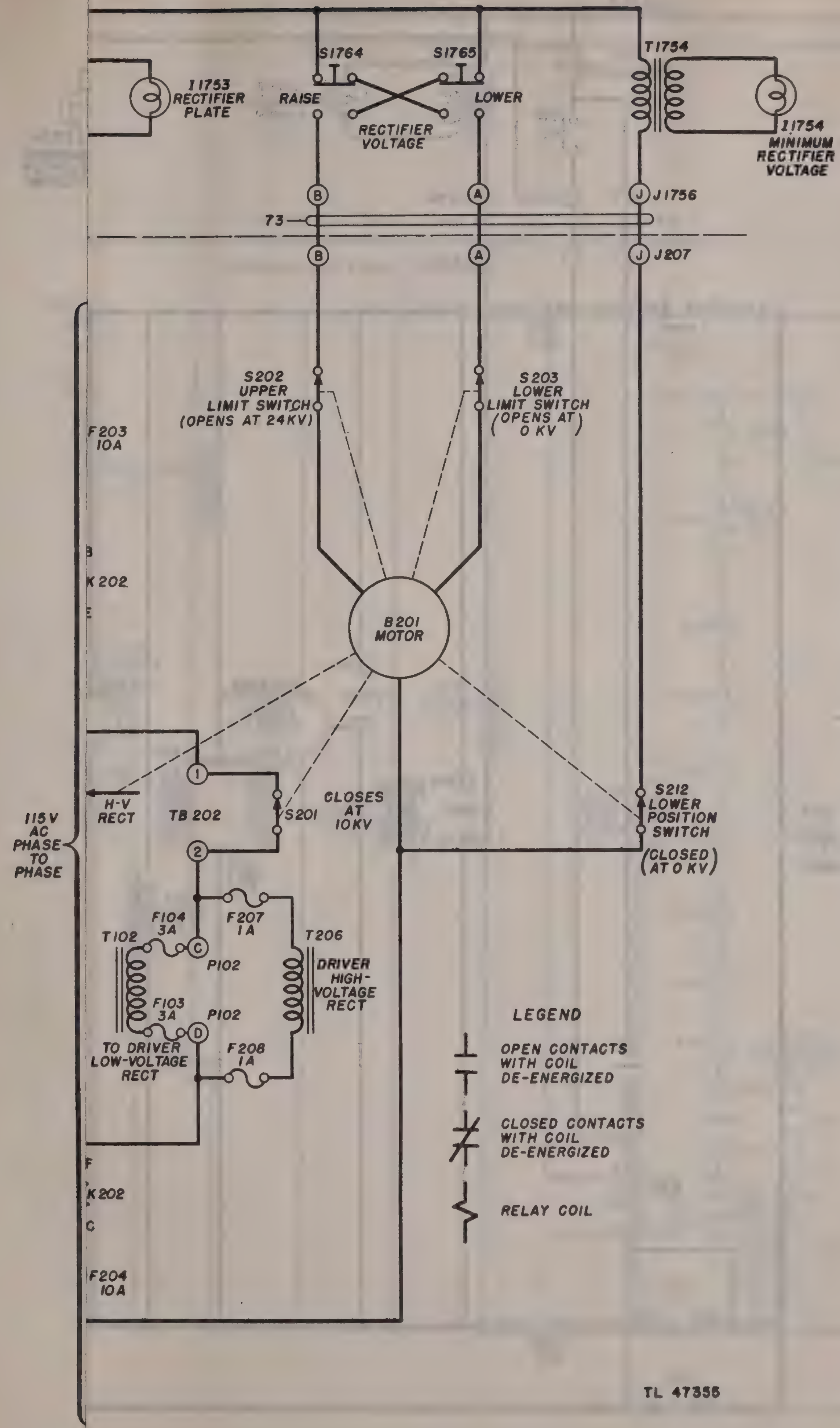


Figure 27. Transmitter control circuit.

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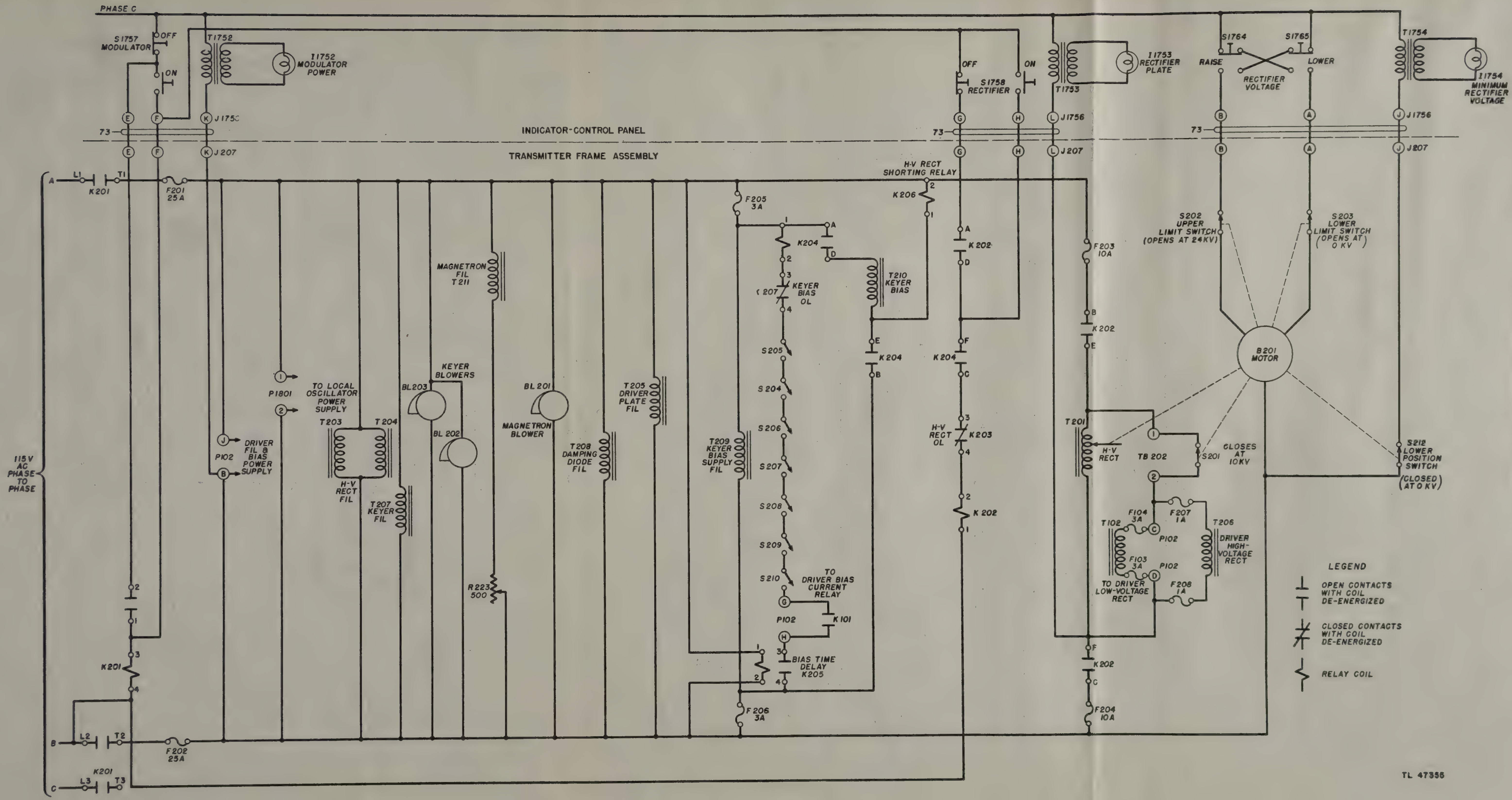

Figure 27. Transmitter control circuit.

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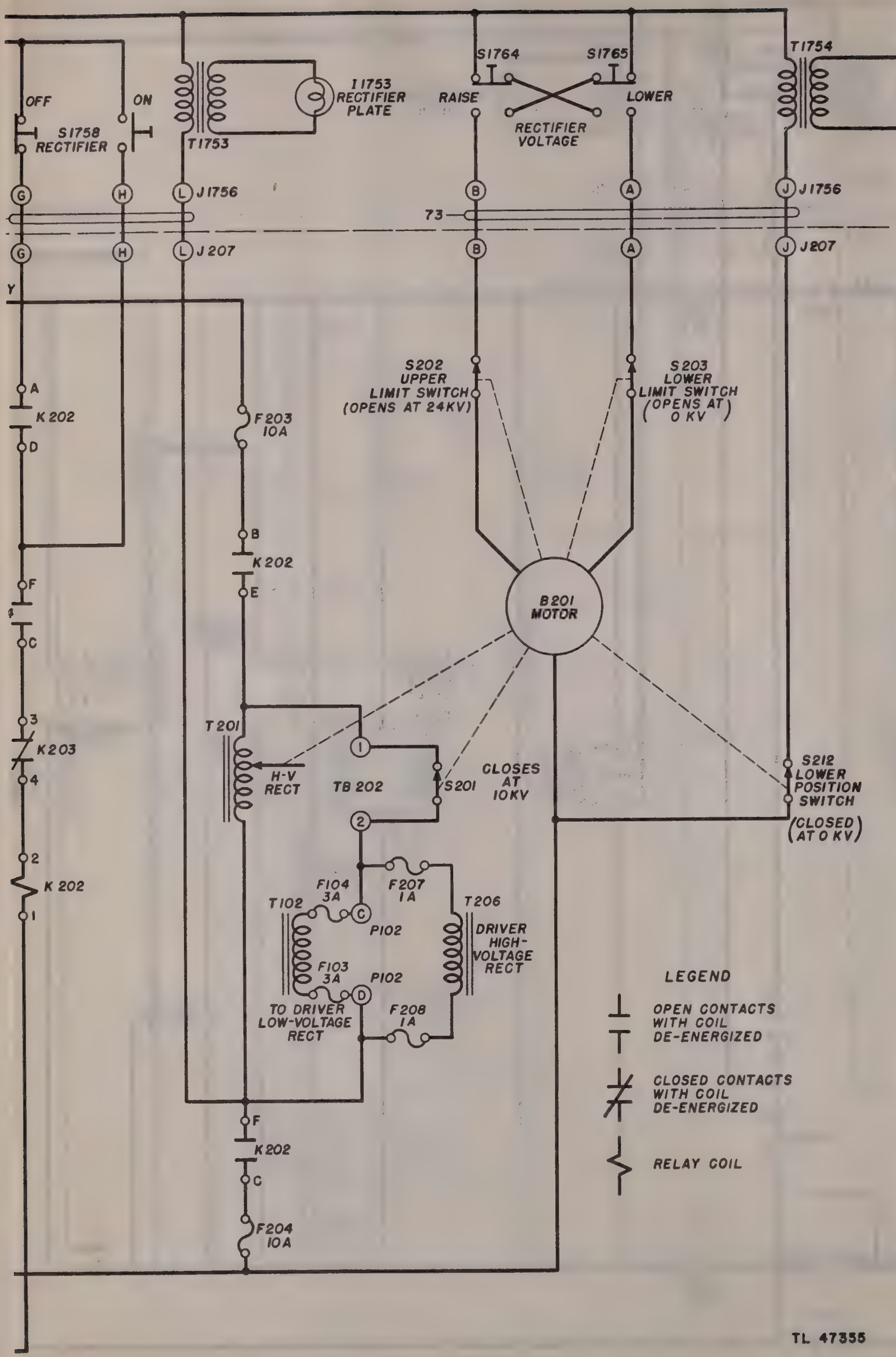

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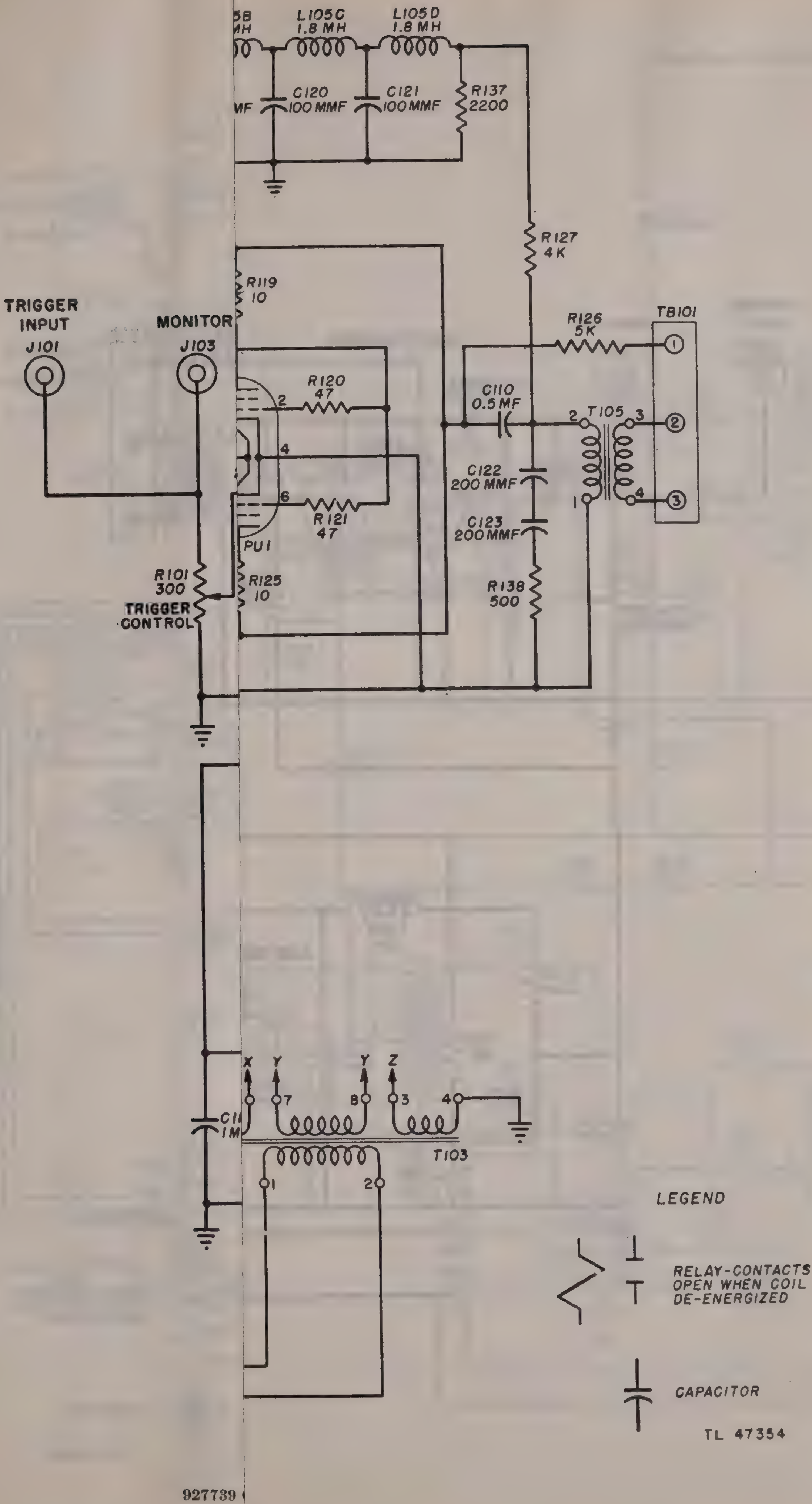

Figure 28. Driver unit, complete schematic diagram.

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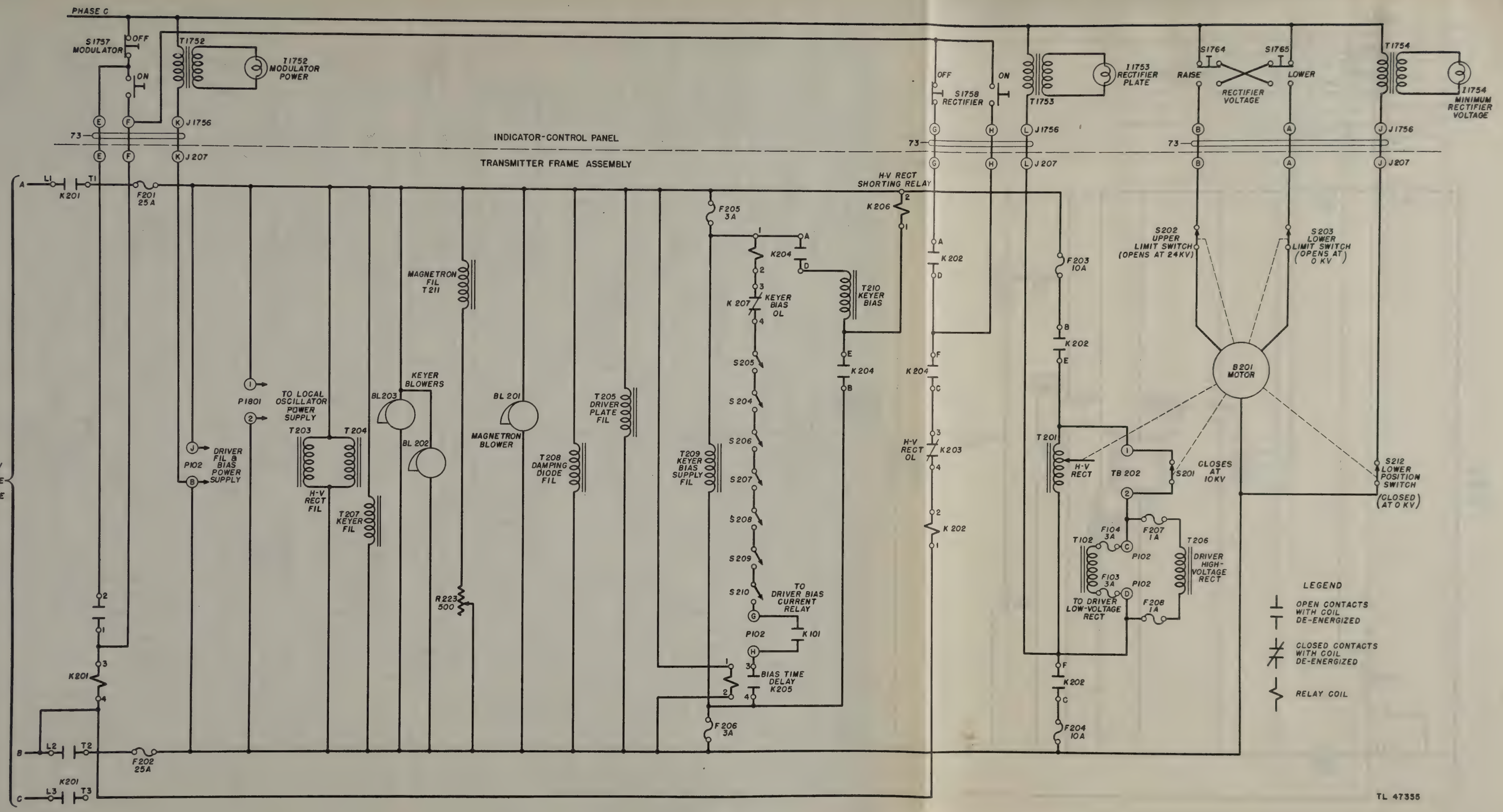

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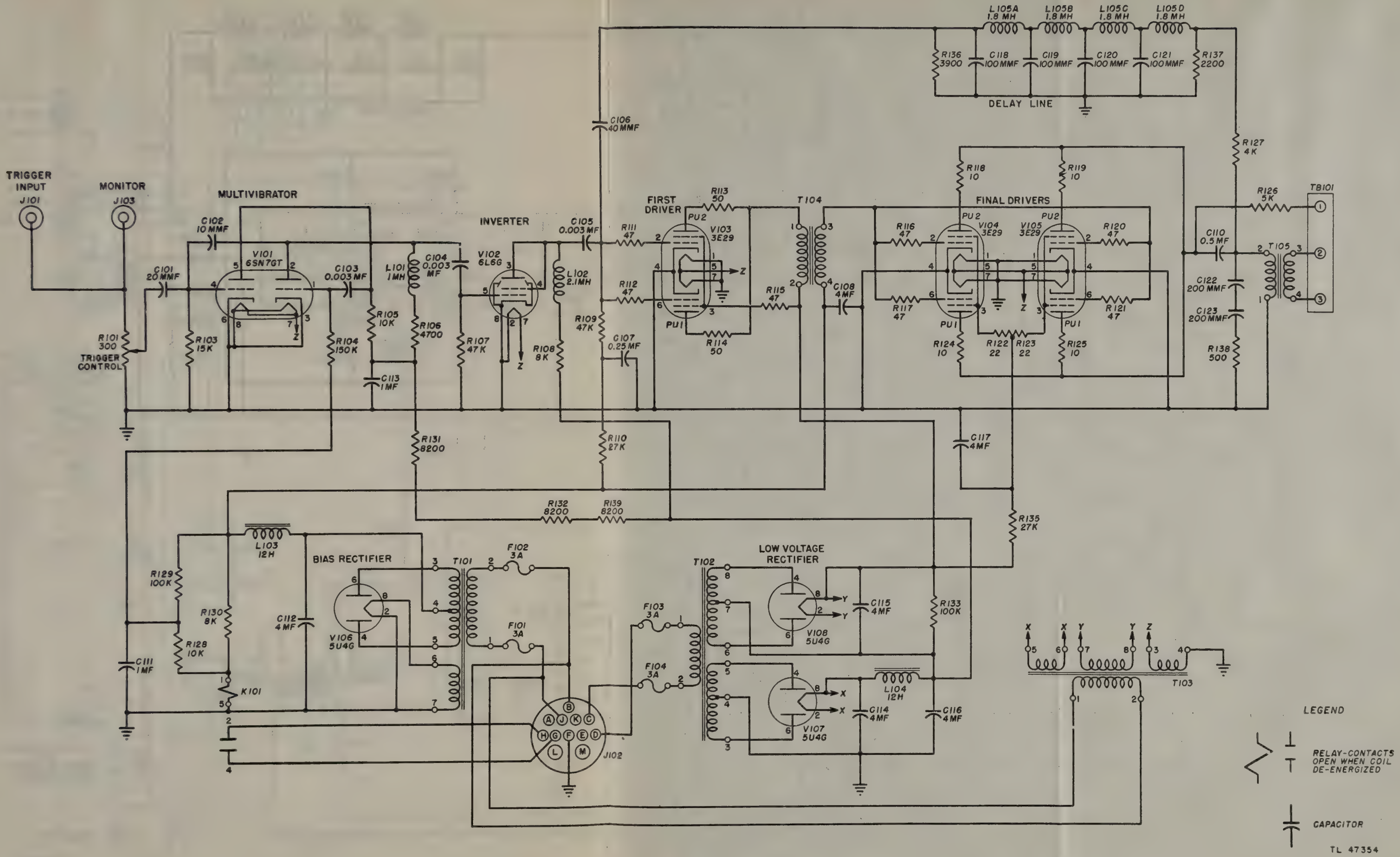

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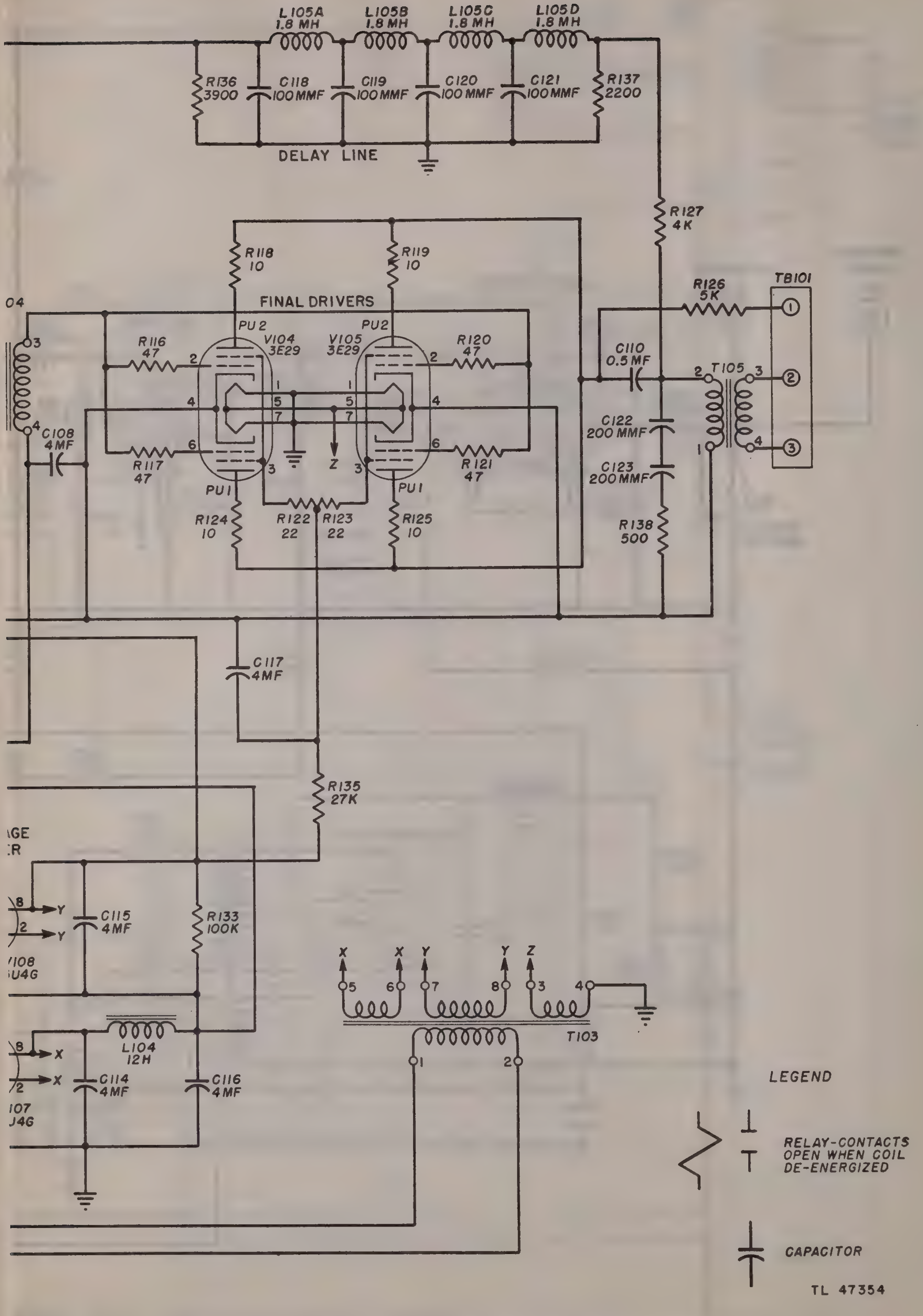


Figure 28. Driver unit, complete schematic diagram.

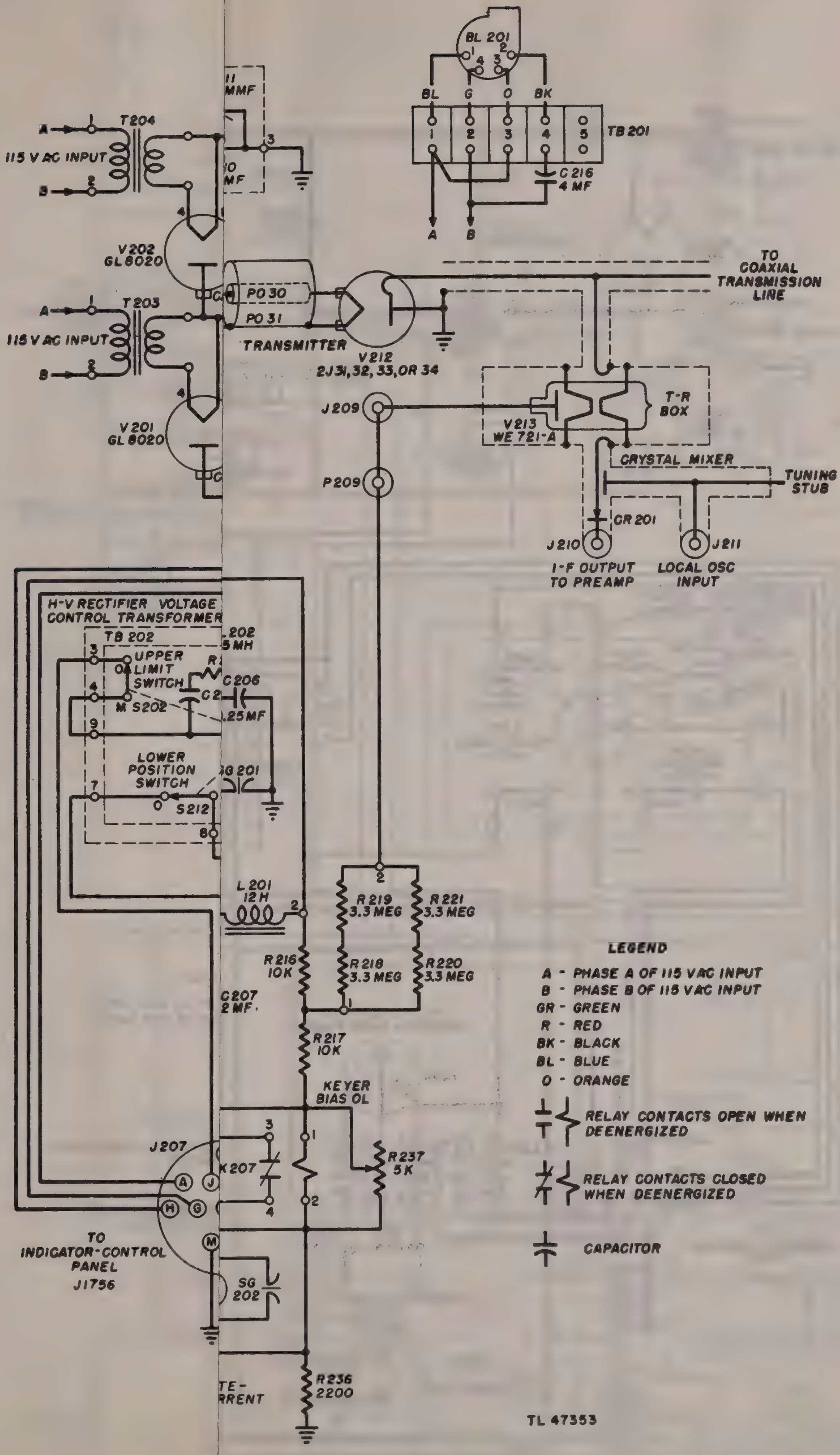


Figure 29. Transmitting system, complete schematic diagram.

Figure 28. Driver unit, complete schematic diagram.

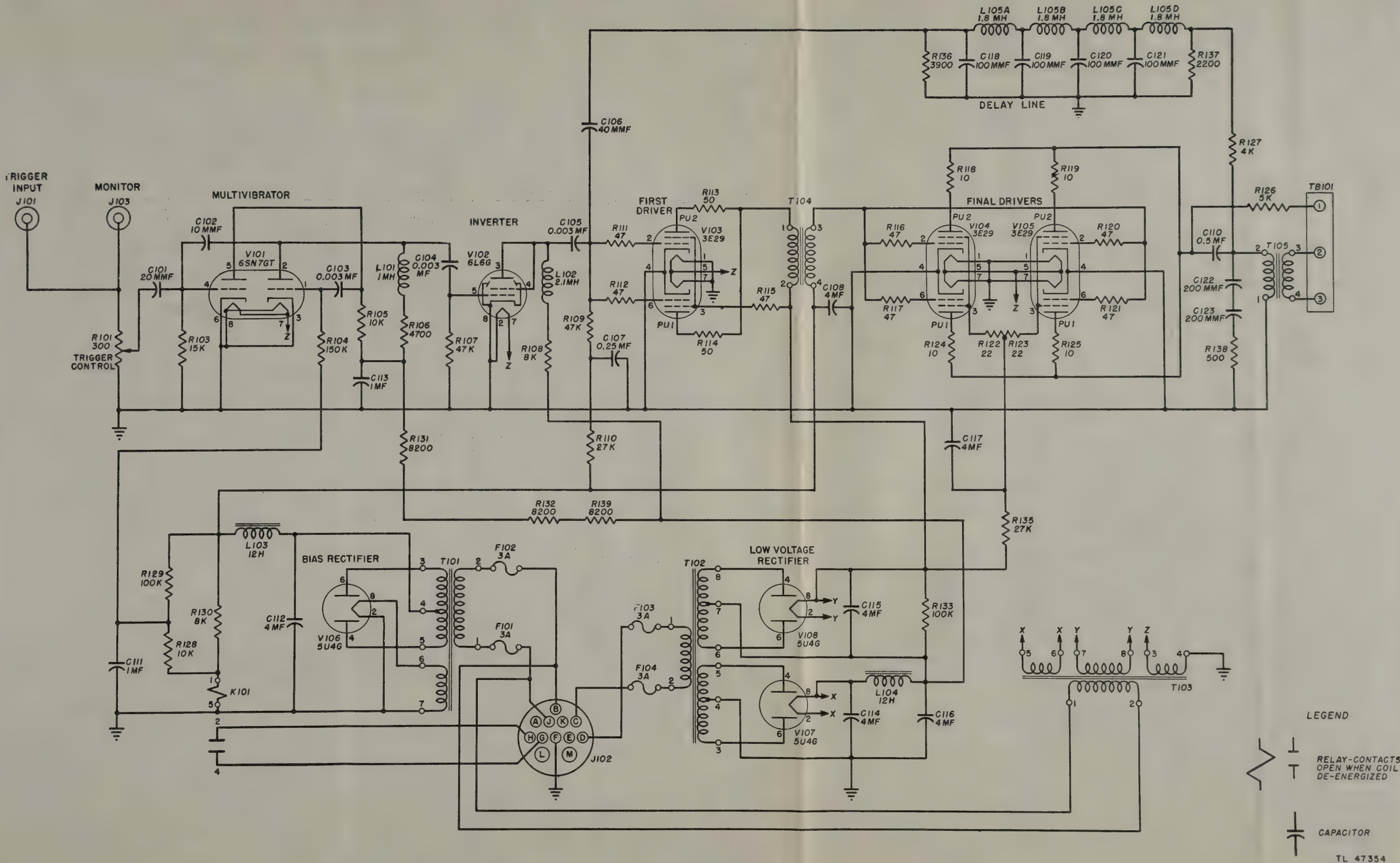
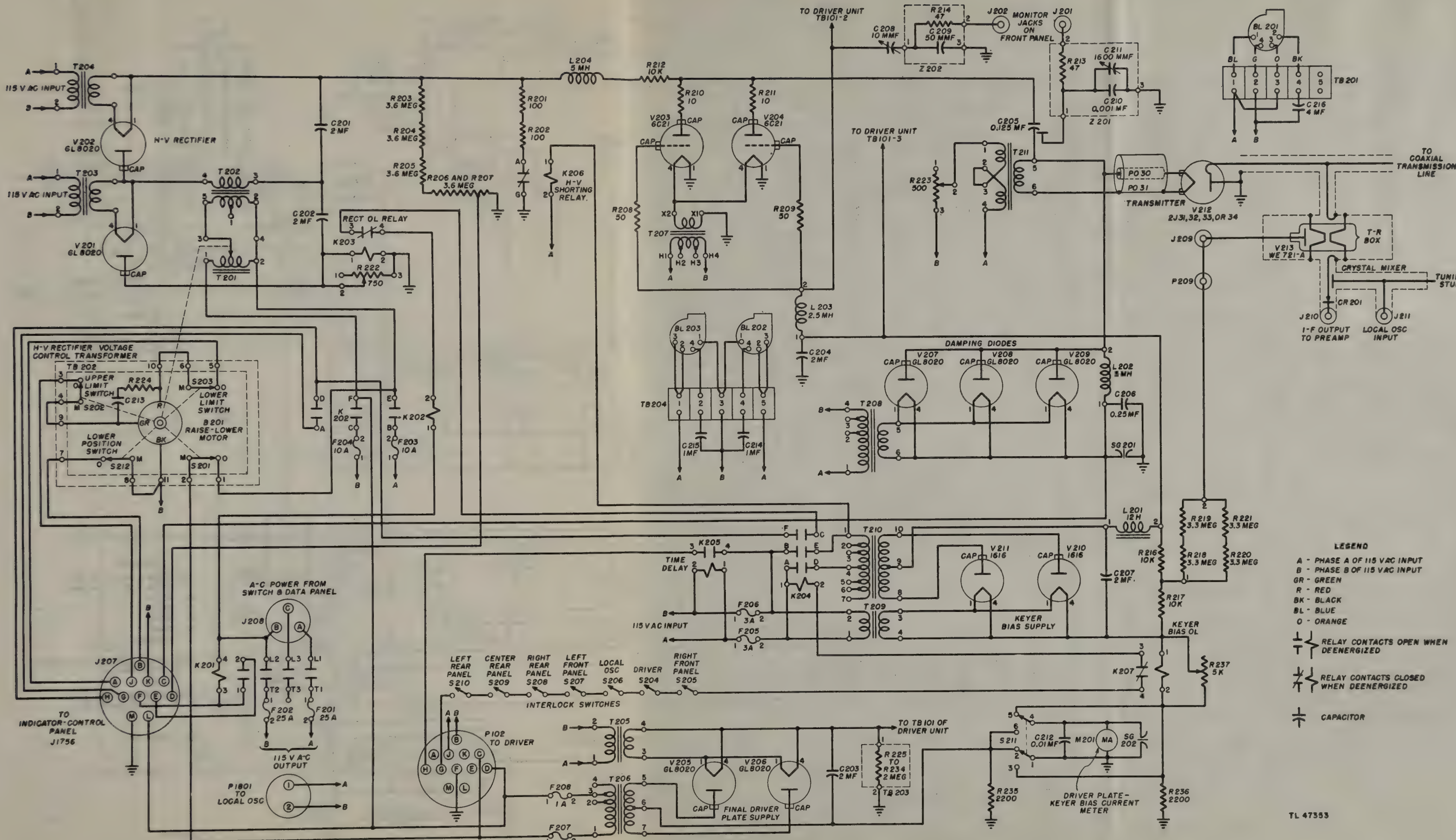


Figure 28. Driver unit, complete schematic diagram.



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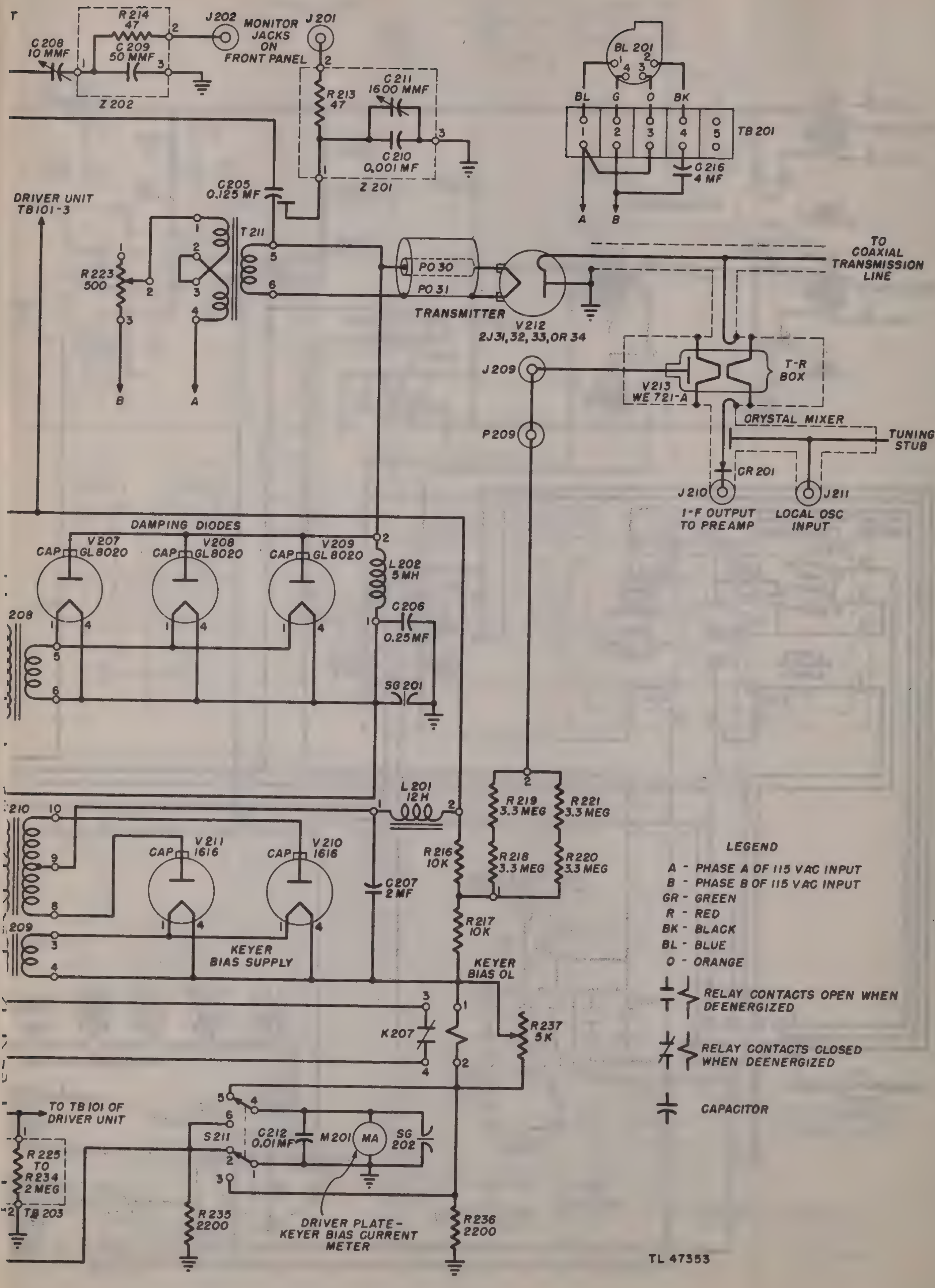

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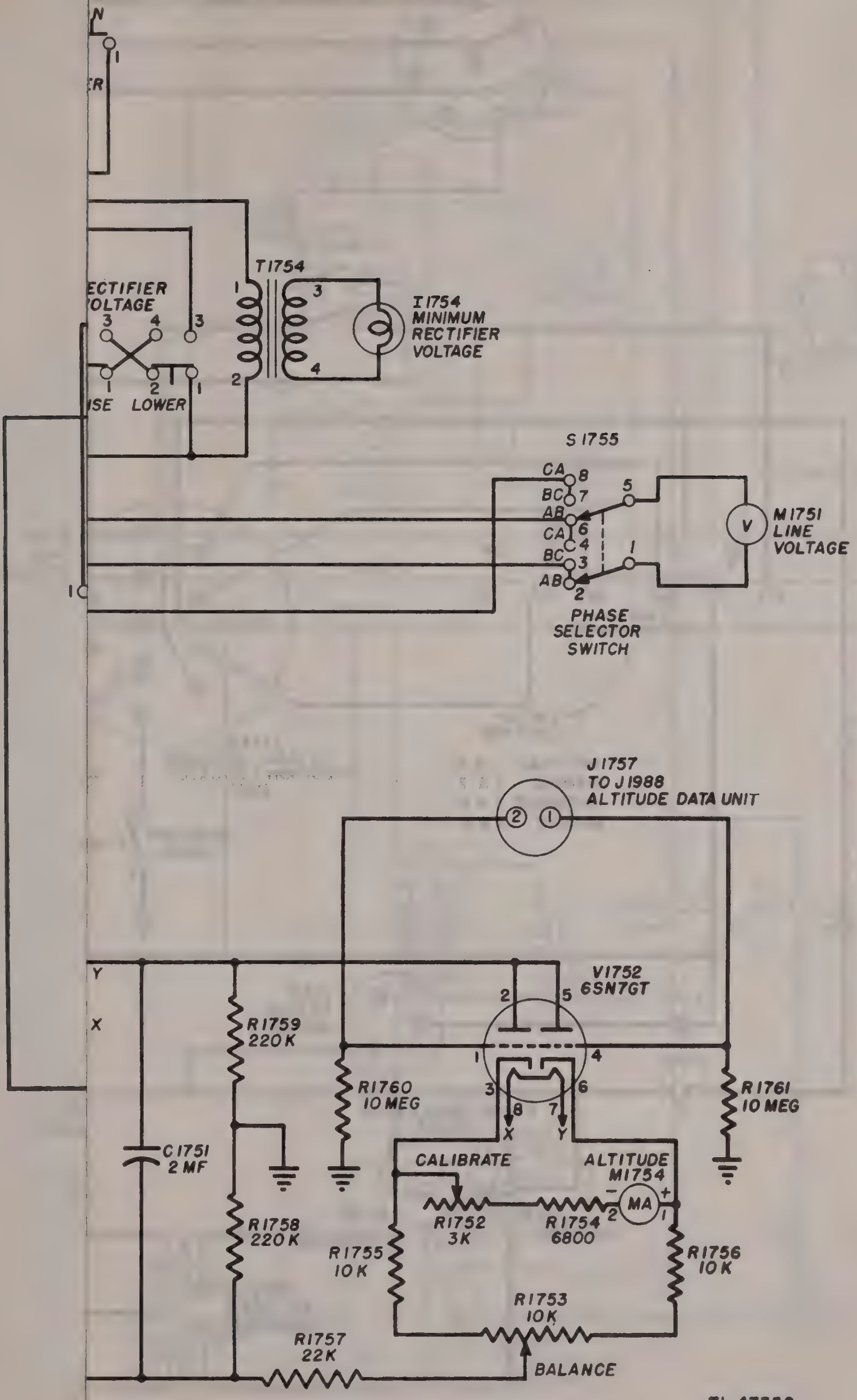
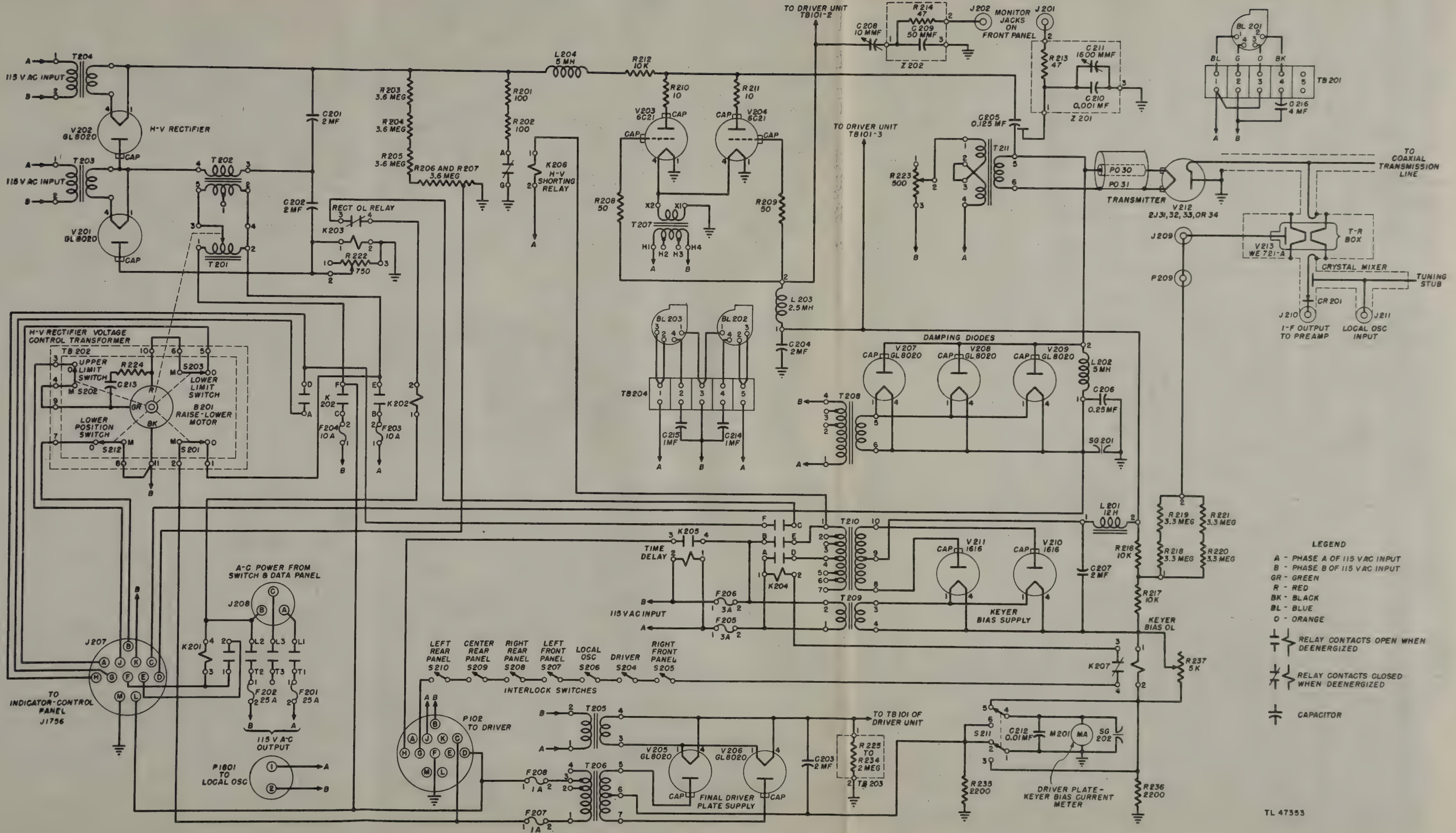


Figure 30. Indicator-control panel, complete schematic diagram.



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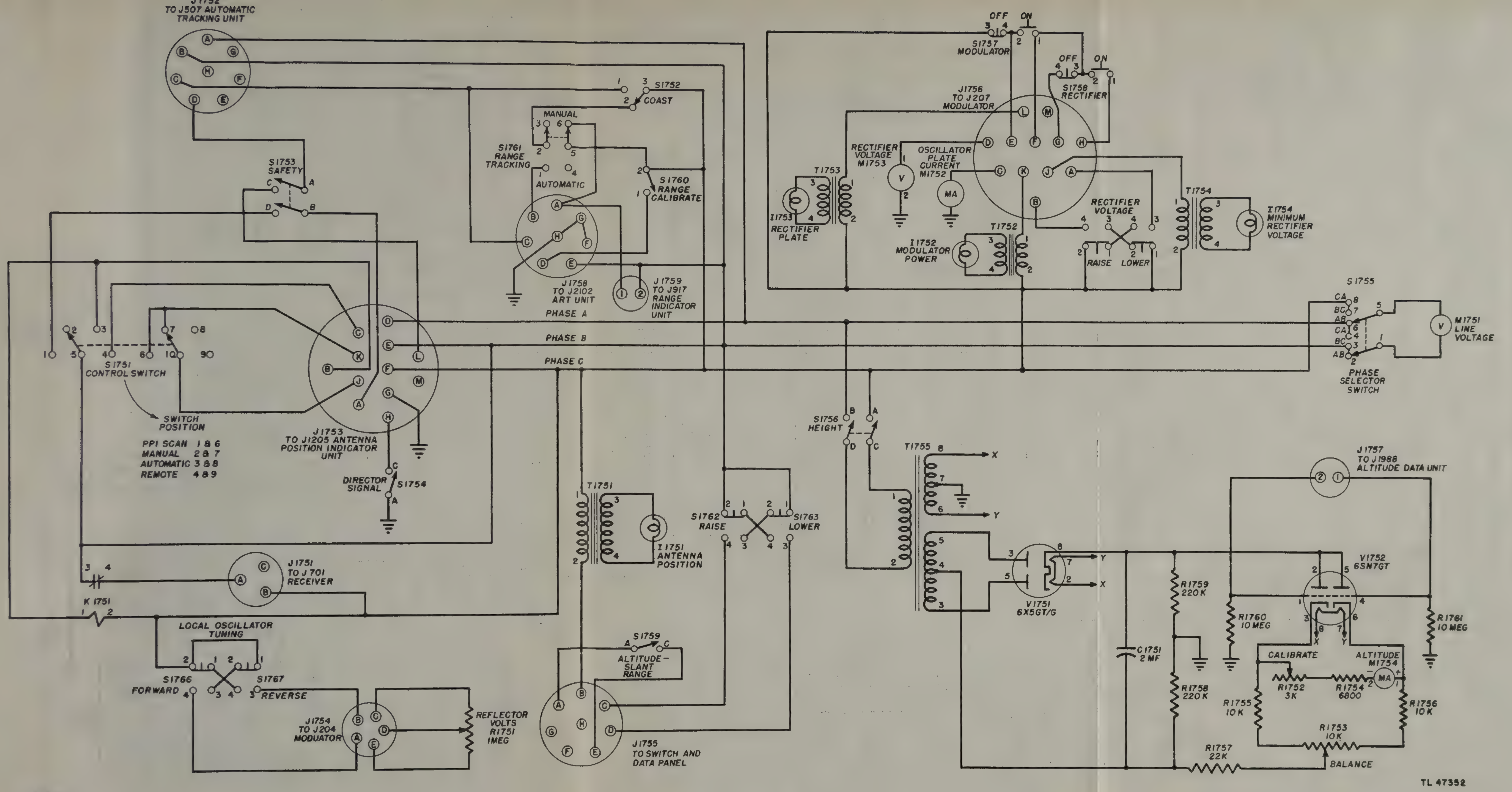

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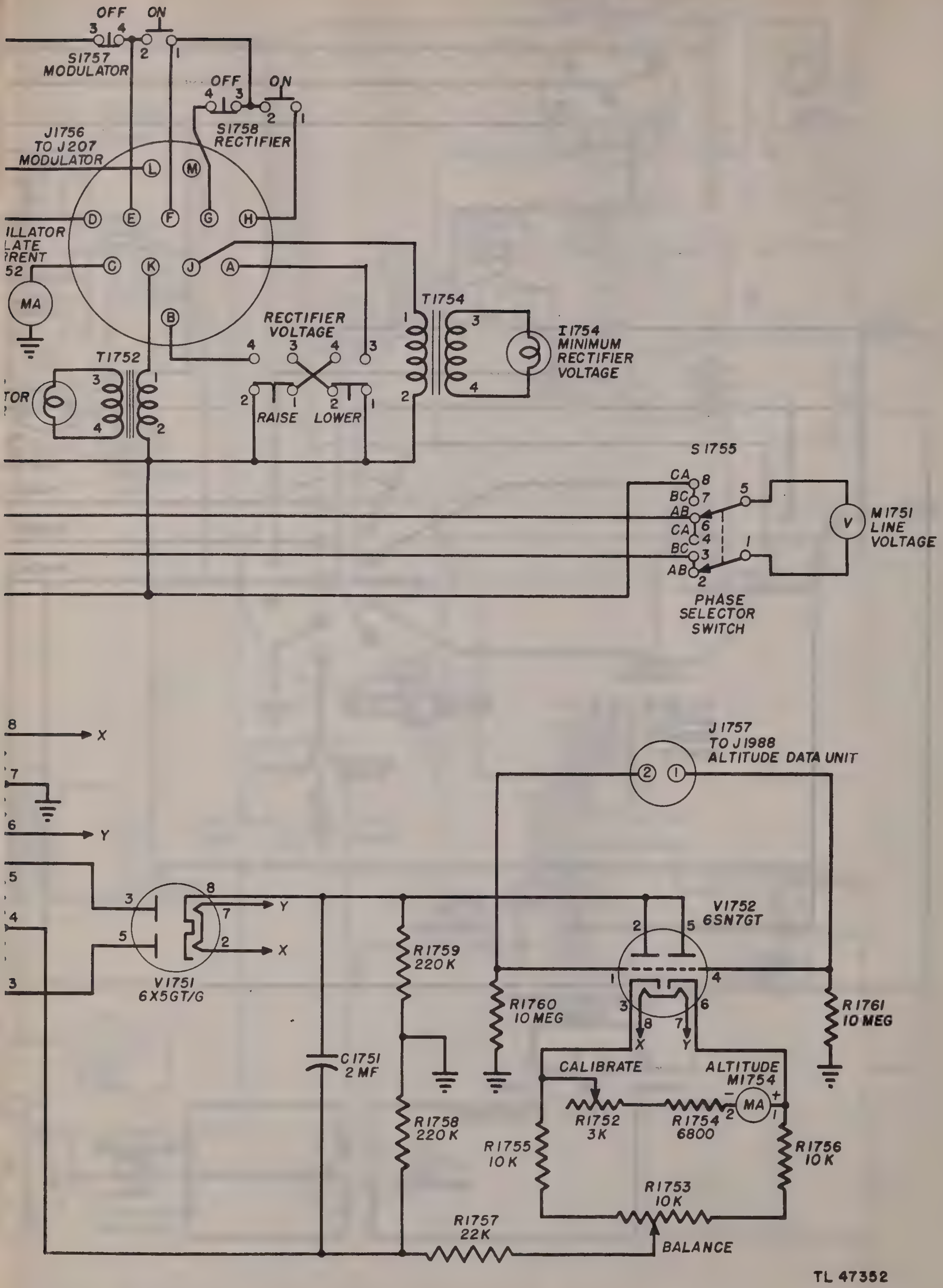

Figure 30. Indicator-control panel, complete schematic diagram.

CHAPTER 3
R-F SYSTEM

SECTION I
INTRODUCTION

33. FUNCTIONS.

The basic functions of the r-f system are to carry the pulses of r-f energy produced by the transmitting system to the antenna, to radiate and focus the pulses in the desired manner and direction, and to receive and convey to the receiving system any target echoes of the radiated energy. In addition to these basic functions, a means of following the target automatically has been developed by the use of conical scanning.

34. BLOCK DIAGRAM OF R-F SYSTEM (fig. 31).

The block diagram shows the components of the r-f system and their relationship to the transmitting and receiving systems. Each of the components described briefly below is discussed in detail later in this chapter.

a. Transmitting-oscillator Coupler. The transmitting-oscillator coupler connects the output of the transmitting oscillator to the r-f line. A tee-junction section is built into the coupler and connects the receiving system branch line to the main r-f line. The transmitting-oscillator coupler and the tee-junction keep the energy of a received echo from being lost in the line to the transmitter.

b. R-f Transmission Line. The r-f transmission line consists of several sections of rigid coaxial line. It connects the transmitting oscillator and the T-R box to the antenna. The sections may be removed easily when repairing or servicing the unit.

c. T-R Box. The T-R box functions as an electronic transmit-receive switch. During the passage of the transmitted pulse it blocks the line to the crystal mixer preventing damage to the crystal by the strong main pulse. In the interval between transmitted pulses when echoes may be intercepted, it serves as an efficient coupling unit from the r-f line to the receiving system.

d. Rotating Joints. There are three rotating joints in the r-f transmission line. One joint enables the antenna and reflector to be rotated in azimuth, another enables the antenna and reflector to be tilted in elevation, and the third, a high-speed joint, enables the dipole antenna itself to be spun at 1,800 rpm. The azimuth and elevation joints are similar mechanically and all three joints are similar electrically.

e. Antenna. The antenna is connected to the r-f transmission line through the high-speed rotating joint. The antenna is a half-wave dipole placed at a critical point inside the reflector so that the transmitted waves are focused into a narrow beam and the echo signals intercepted by the reflector are focused on the dipole.

35. LOCATION OF PARTS.

The location of the various parts of the r-f system with respect to the pedestal and modulator, is shown in figures 32 and 33.

a. R-f Head (fig. 32).

(*1*) The transmitting oscillator is located in a special compartment (r-f head) on top of the transmitter frame assembly and joined directly to the oscillator output is the transmitting-oscillator coupler and the tee-junction.

(*2*) From the tee-junction the r-f line branches at right angles to the T-R box and the crystal mixer. The T-R box is located in this branch line, close to the transmitting-oscillator coupler, and receives its input connection from the tee-section.

b. Rotating Joints (fig. 33).

(*1*) The azimuth rotating joint is located at the center of the pedestal base.

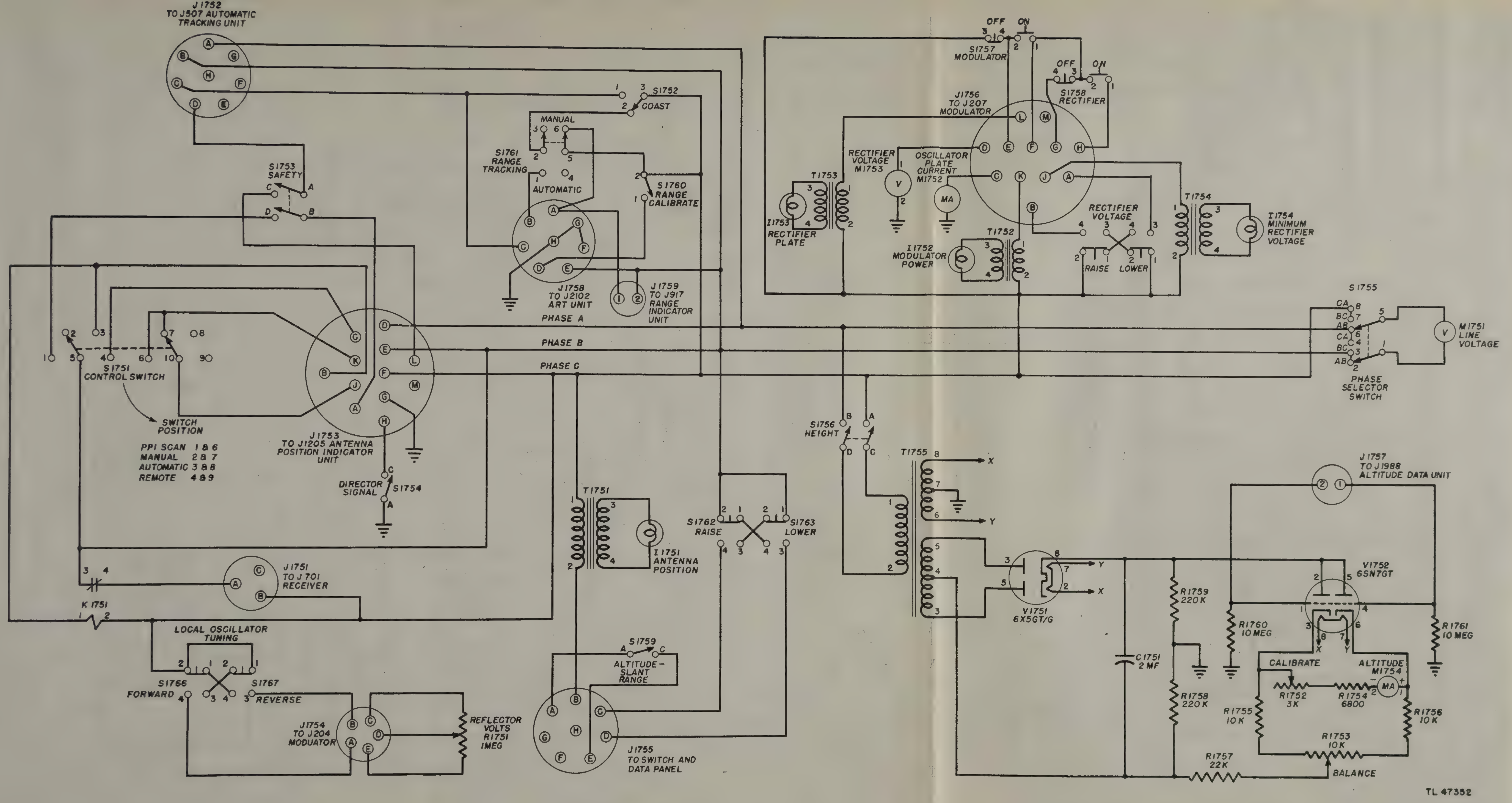

Figure 30. Indicator-control panel, complete schematic diagram.

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R-F SYSTEM

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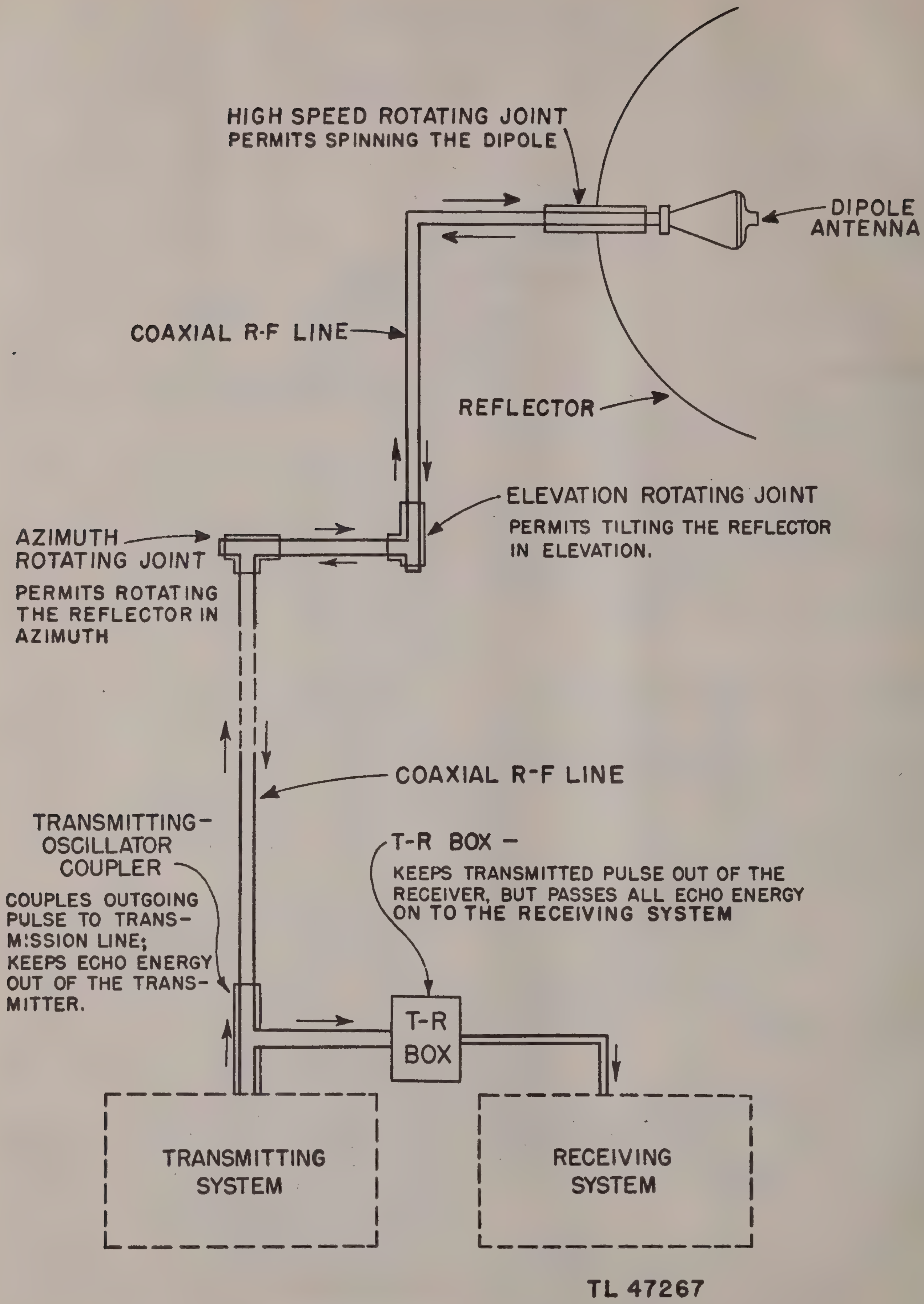


Figure 31. R-f system, block diagram.

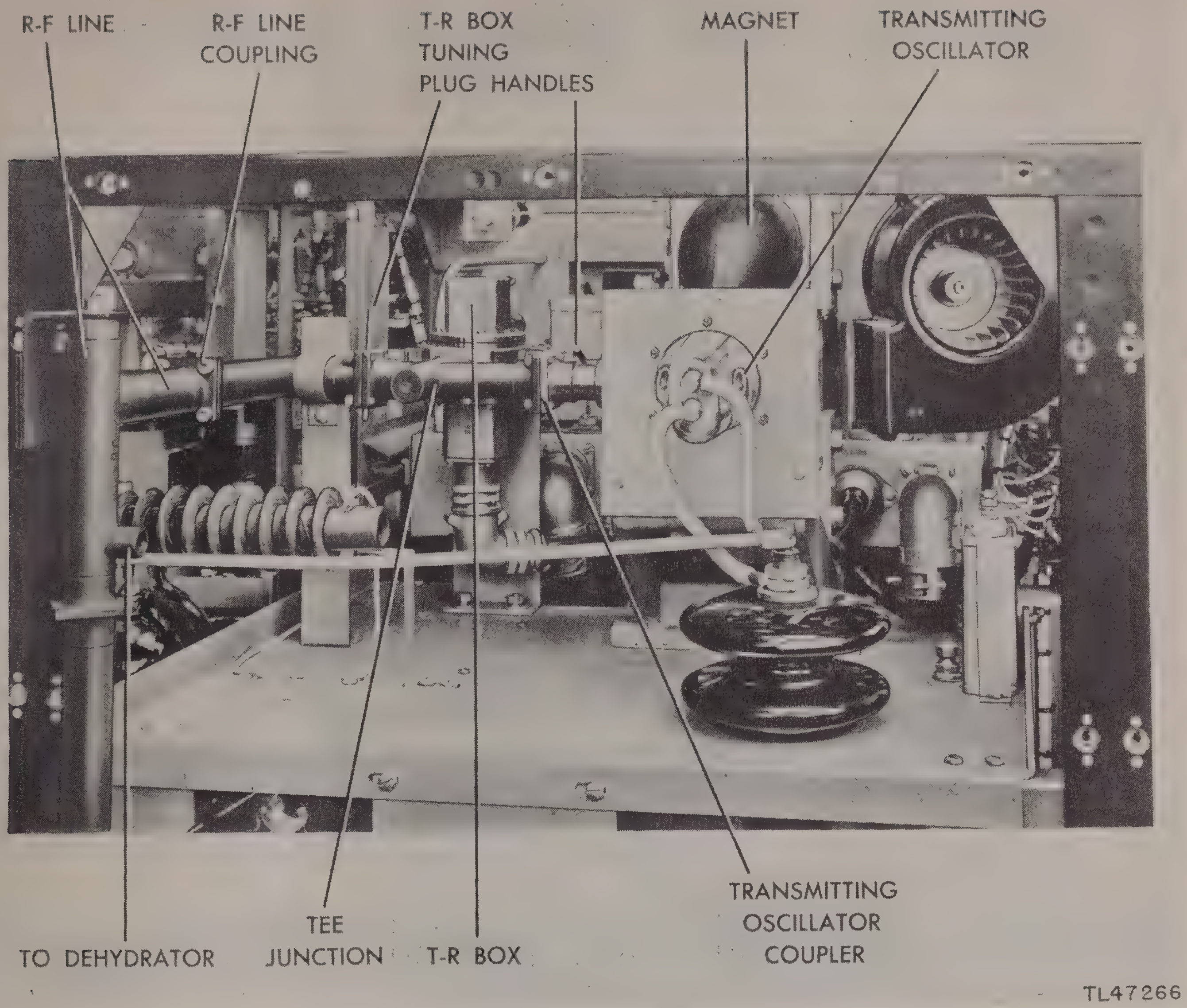


Figure 32. R-f system, location of parts in transmitter frame assembly.

(*2*) The elevation joint is located at the rear of the reflector below and to one side of the reflector center.

(*3*) The high-speed joint is slightly to the rear of the center of the reflector.

c. Antenna (fig. 33). The antenna pedestal is permanently mounted on top of the trailer.

d. Dehydrator (fig. 9). The dehydrator is located in the right front section of the trailer and behind the switch and data panel. It is shock-mounted to the floor.

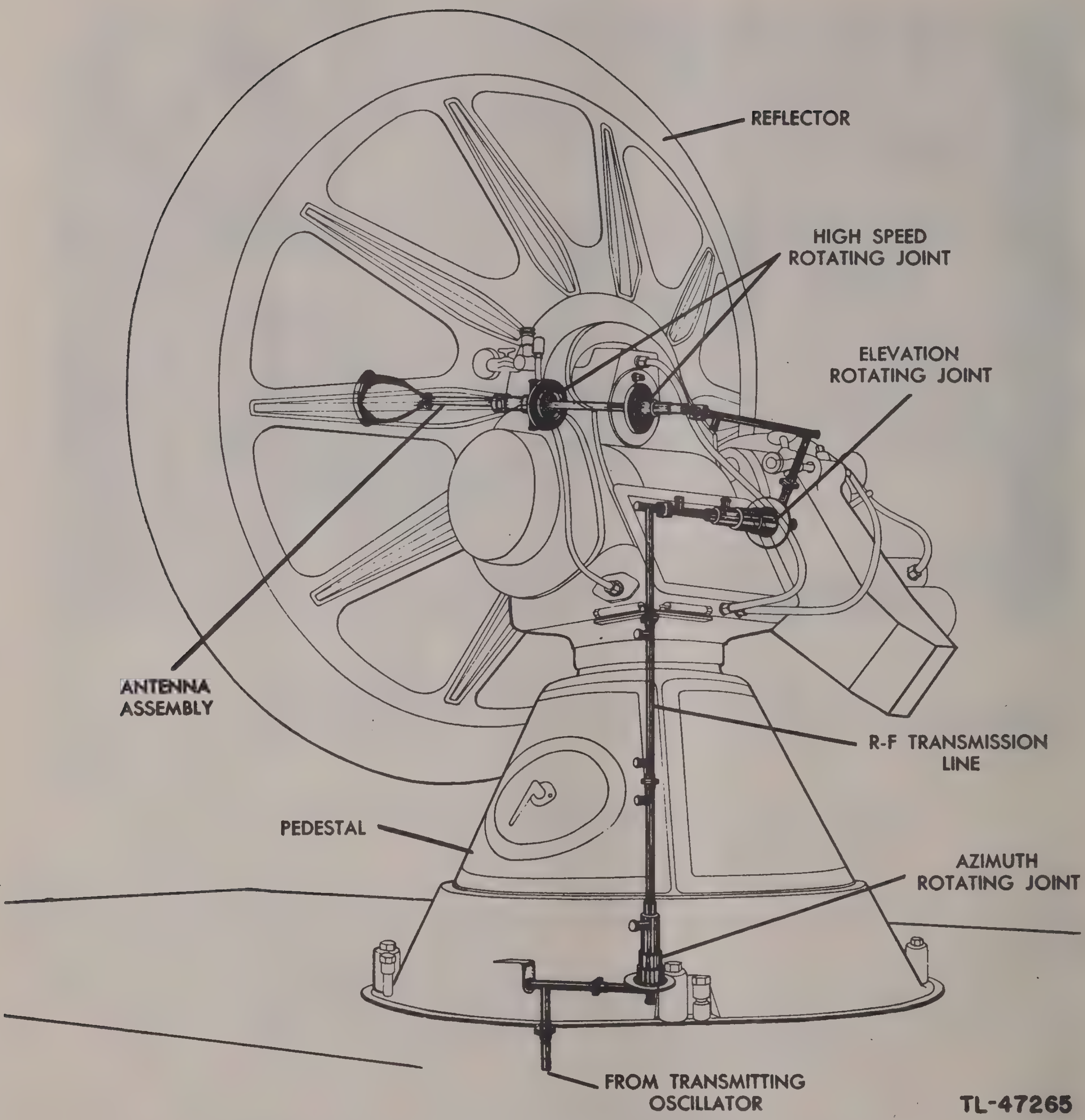


Figure 33. R-f system, location of parts in pedestal.

SECTION II
TRANSMITTING-OSCILLATOR COUPLER

36. GENERAL.

The transmitting-oscillator coupler (fig. 34) has two main functions; to couple the output of the transmitting oscillator to the r-f line, and to prevent the echo signals from entering the section of the transmission line to the transmitter where their energy would be wasted. The coupler is a section of rigid coaxial line. It consists of two parts: the transformer section which matches the transmitting oscillator to the r-f line, and the built-in tee-junction. The construction provides coupling to the magnetron (par. 37), a path for the transmitted energy to the antenna, and a coupling and a path for the reflected energy to the receiver.

37. CONNECTION TO TRANSMITTING OSCILLATOR.

The output prong of the transmitting oscillator is a ⅛-inch tungsten rod approximately 1-inch long. This prong is gripped tightly by spring fingers which care constructed as part of the center conductor of the coupler. The outer conductor is connected to the head of the transmitting oscillator by the coupling ring which is screwed down on the threaded fitting on the oscillator head. This connection should be removed and replaced only when installing a new transmitting oscillator.

38. TEE-JUNCTION.

The tee-junction is formed at the intersection of the branch line to the receiver with the main transmission line. The intersection is at right angles, and the center conductors at this point are supported by a quarter wave stub (par. 41). The short section of the receiver line that forms part of the coupler ends in a connection to the input fitting of the T-R box. The input to the T-R box is a coupling loop formed by the inner conductor of the line being looped over and shorted to the outer conductor. The connection from the other arm of the tee-junction to the

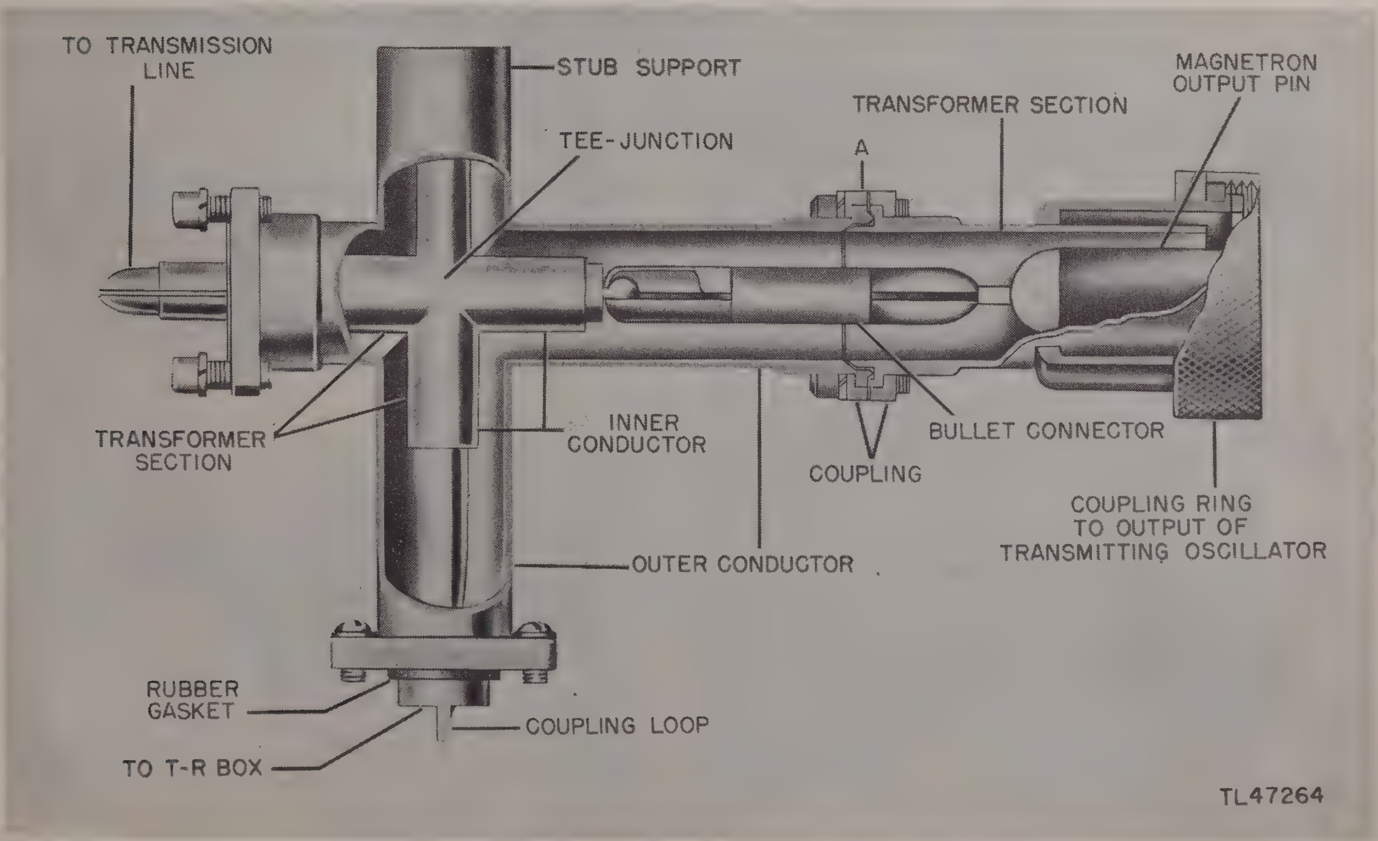


Figure 34. Transmitting-oscillator coupler.

transmission line to the antenna is made through a standard line connector (par. 42).

39. OPERATION.

a. The operation of the transmitting-oscillator coupler is such as to cause practically all the energy of an echo to go into the receiver line. This action depends on the critical distance between the coupling to the transmitting oscillator and the branch line to the T-R box, and on the fact that the transmitting oscillator has a high impedance during the "cold" part of its cycle; that is, when it is not transmitting. The tee-junction is placed at such a distance from the connection to the oscillator that the entire short section of line between the tee-junction and the oscillator presents a high impedance to an echo signal trying to enter the line. This distance is a half-wave (or any multiple of a half-wave) which acts as a 1 to 1 transformer and repeats at the tee-section the high impedance of the magnetron at the other end. The echo signal is thus blocked in this section of the line and goes into the low-impedance branch line to the T-R box.

b. During the transmitted pulse this section of line still acts as a 1 to 1 transformer and couples the low impedance of the operating transmitting tube to the tee-junction, thus providing a low-impedance path for the r-f energy from the transmitter to the r-f line.

SECTION III

R-F TRANSMISSION LINE

40. GENERAL.

a. Construction. The sections of coaxial transmission line used with this set consist of ⅞-inch rigid copper tubing containing a smaller inner copper tube which is supported within the outer tube by stub supports placed at intervals along the line. These rigid sections extend from the antenna to the coupling at the rear of the transmitter frame assembly. The rotating joints are mounted in these sections.

b. Operation. A coaxial line is used to conduct the r-f energy produced by the magnetron to the antenna and the return echo signals to the receiver because the coaxial line has several operating advantages which makes its use in this set an efficient method of energy transmission. As the over-all length of the line is relatively short, the loss for any given section of line is low. Thé inner conductor is entirely shielded by the grounded outer conductor. This allows the magnetic and electric fields to exist only in the space between the two conductors and eliminates radiation losses. The shielding also prevents noise pick-up from other lines nearby.

41. SUPPORTING STUBS (figs. 35 and 36).

The presence of a support of some kind is necessary at intervals along the line to keep the inner conductor centered properly within the outer conductor. At first glance a metal stub of the type shown in figure 35 looks like a short-circuit between the inner and outer conductors. However, since the lehgth of the stub is equal to ¼ wavelength approximately, the radio waves travel past the stub support without any appreciable interruption or loss of energy. The larger diameter of the inner conductor near the stub makes the stub function efficiently over a band of frequencies. At several places along its length, the r-f line makes sharp right-angle turns. Where these turns occur, other stub supports are found, which function in the same way as the one just described. A typical right-angle stub is shown in figure 36. The smaller diameter of the inner conductor near the corner or bend makes the stub function more efficiently over a band of frequencies.

42. LINE CONNECTORS (fig. 37).

In joining together two sections of r-f transmission line, it is necessary to connect both outer conductors and both inner conductors as

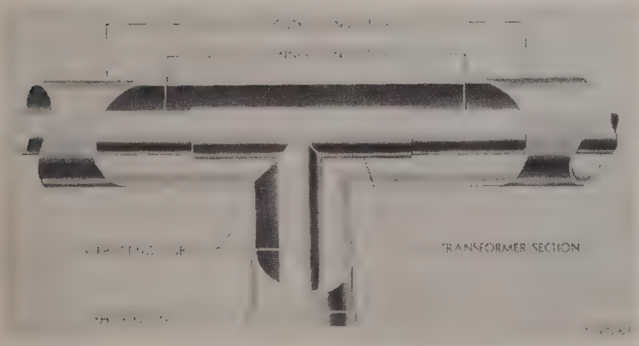


Figure 35. Straight line transmission line stub support.

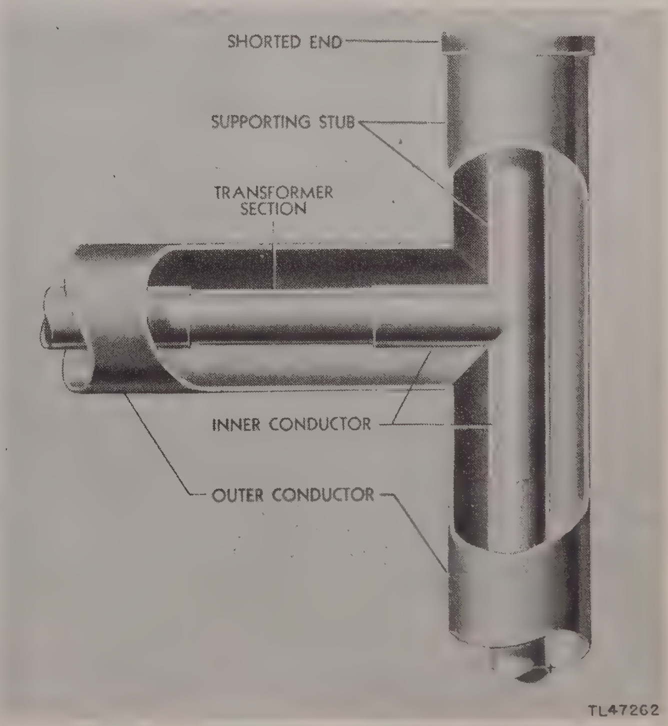


Figure 36. Right-angle transmission line stub support.

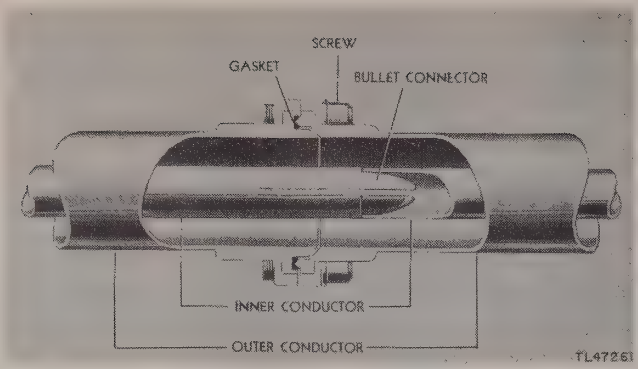


Figure 37. Transmission line coupling.

smoothly and closely as possible, as any irregularities impede the flow of energy and may possibly cause arc-overs. The outer conductors are beveled to match each other and are provided with flanges at the open ends. These flanges are joined to one another by screws which, when tightened, bring the metal outer conductors into close contact. A circular rubber gasket seals the connection so that it is airtight. The center conductors are joined tightly by means of a bullet connection which is constructed as a permanent part of one of the two center conductor sections and is inserted into the open end of the matching center conductor. The end of the bullet is slotted and spread to provide a spring action which insures a tight contact.

SECTION IV
T-R BOX

43. GENERAL.

a. Purpose. The T-R box serves as a high-speed electronic valve or switch which permits all the energy of a received echo to pass to the receiver, but prevents the high energy of the transmitter pulse from passing into the receiving system.

b. Description. The T-R box is shown in figures 38 and 39. The T-R box, together with the copper flanges of the T-R tube forms a cavity (fig. 40) whose internal size can be varied by means of two threaded plugs which are screwed in or out from opposite sides of the cavity. These plugs are used in tuning the cavity to the oscillator frequency. The input to the T-R box is through the short section of the r-f line leading from the tee-junction (fig. 32). The end of this line, which connects to the T-R box, terminates in a coupling loop made by joining the inner and outer conductors of the line (fig. 38). This input coupling loop is inserted into the T-R cavity at the factory, and secured tightly in place by screws which pass through a flange on the end of the section of r-f line. The loop is part of the tee-section and is not adjustable. The output from the T-R box is fed to the crystal mixer through a second coupling loop, identical with the input coupling loop, but inserted into the T-R cavity at the diametrically opposite point and secured in place by means of screws and a flange. This connection can be loosened, if desired, and the coupling loop rotated inside the cavity for maximum energy pick-up when tuning the T-R box. The top end cap of the T-R box (fig. 39) is a protective cap over one end of the T-R

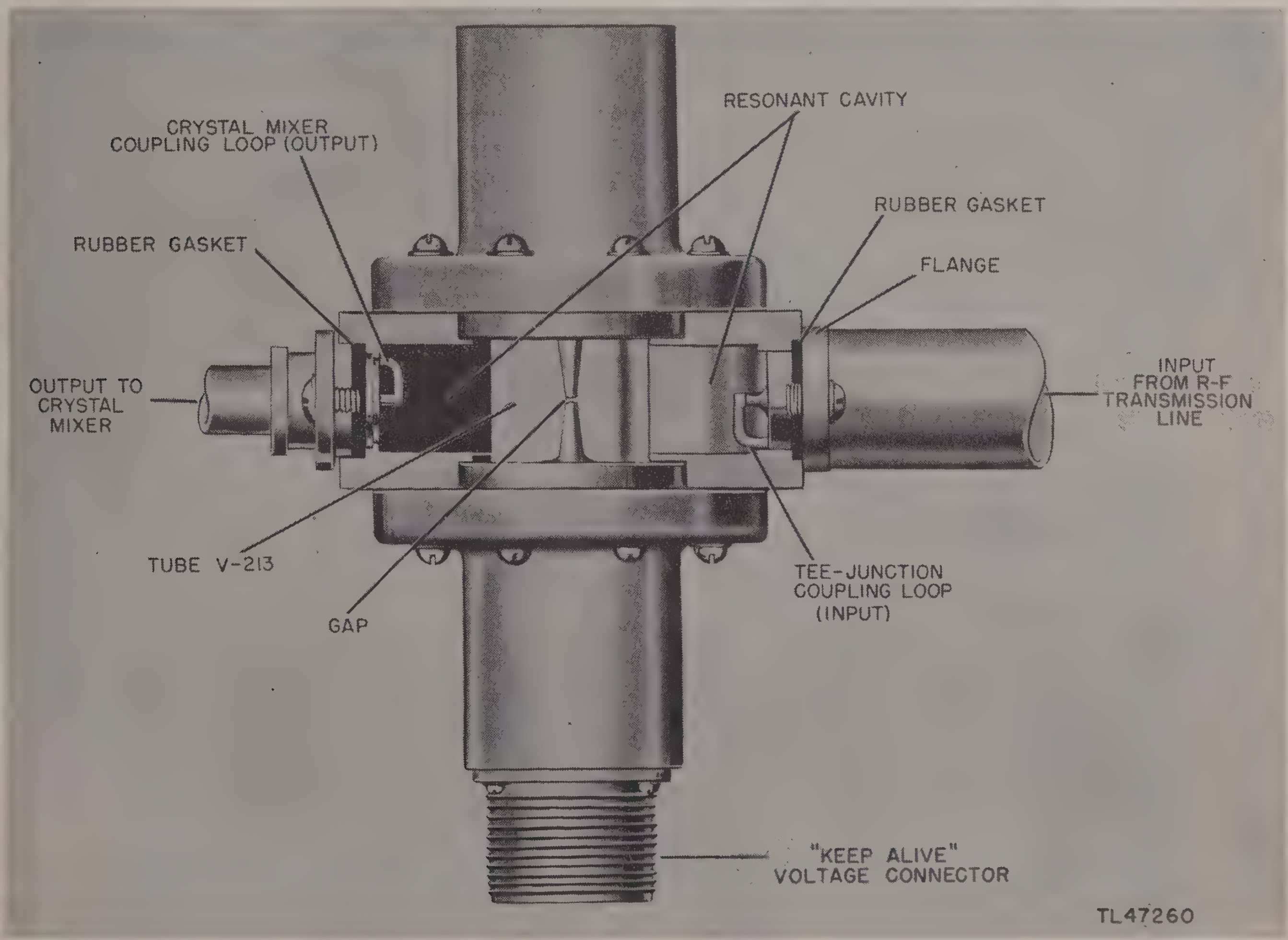


Figure 38. T-R box, showing coupling loops.

tube. The bottom end cap is provided with a threaded fitting for connection of the cable supplying keep-alive voltage to the T-R tube.

44. T-R TUBE (fig. 41).

The T-R tube is a partly evacuated glass tube. Sealed into it are two copper disks which project outside the tube in the form of two parallel circular flanges (fig. 41). Inside the tube, these two copper disks are drawn into opposing hollow, truncated cones that are separated at their tops by a small gap. Inside one of the cones is the keep-alive electrode which passes through the tube to the metallic cap on the end of the tube. When the keep-alive voltage (approximately 700 volts) is applied to this electrode the space near the tops of the cones becomes filled with electrically charged particles or ions, and provides an easy conducting path for the discharge of any voltage applied across the cones themselves.

45. OPERATION OF T-R BOX.

a. General. The operation of the T-R box can be explained simply by comparing it with its equivalent electrical circuit (fig. 42). A T-R box behaves much like a tuned circuit consisting of an inductance and a capacitance. If an alternating voltage is applied to the circuit, strong

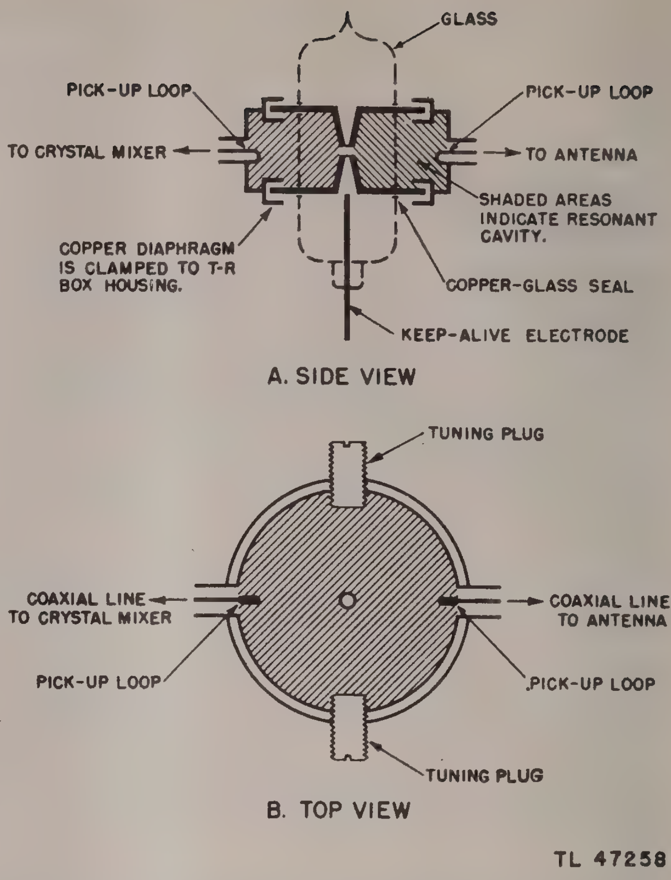


Figure 40. T-R box, simplified diagram showing resonant cavity.

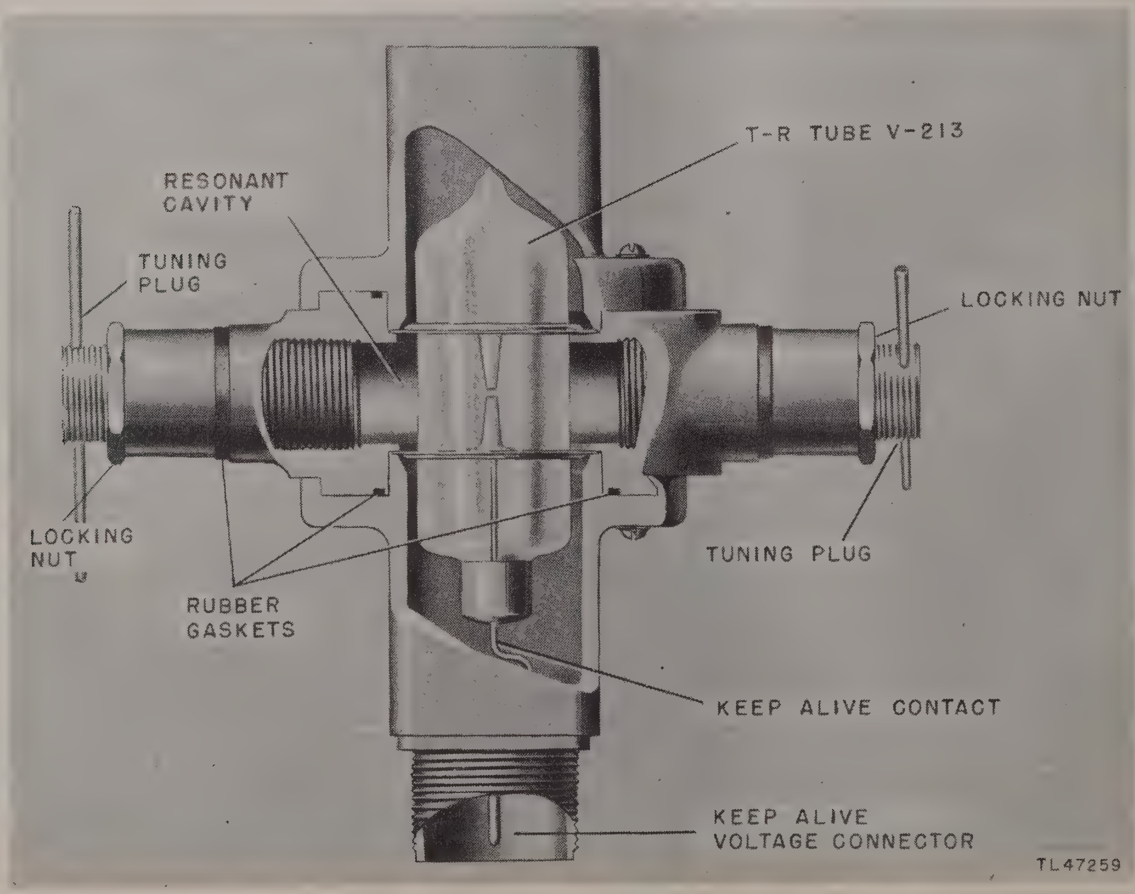
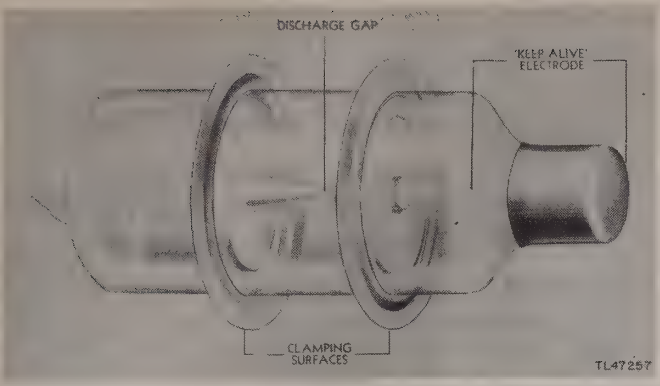


Figure 39. T-R box, showing tuning plugs.



electric oscillations are built up in the circuit, provided the applied frequency equals the resonant frequency of the tuned circuit. Simple resonant circuits are commonly used as highly efficient coupling circuits in radio receivers, and an important point to note is that the effectiveness of the coupling action depends on having the circuit tuned accurately to the frequency of the radio signal. The similarity between this action and that of the action of the T-R box coupling the received signal to the receiving system, is explained in subparagraph **b** below.

b. Action During Reception.

(*1*) Figure 42 illustrates the action of the T-R box during the reception of echo signals. To any r-f energy entering through the input coupling loop A, the cavity of the T-R box resembles a tuned circuit, with the gap between the cones inside the cavity represented by the spark-gap shown in the drawing. The cavity has a definite resonant frequency, which is changed by varying the settings of the tuning plugs (par. 43**b**). If the cavity is tuned by means of these plugs to resonate at the frequency of the incoming echo signal, the echo energy entering the cavity through the input coupling loop A builds up strongly inside the cavity, and is picked up inductively by the output coupling B and sent on to the crystal mixer.

(*2*) In figure 38, it is seen that the input and output coupling loops are lying in the same plane and not tilted at different angles. This arrangement of the loops produces the strongest coupling action, although the relative positions of the loops is not as important as the proper tuning of the cavity by means of the tuning plugs. The output fitting on the T-R box can be loosened and the output coupling loop rotated, to position it parallel to the input loop. This adjustment is necessary in the tune-up procedure whenever the T-R box is taken apart for any purpose, such as the replacement of a faulty T-R tube.

(*3*) As long as the keep-alive voltage is applied to the electrode inside the T-R tube the space between the tops of the cones in the tube is partially ionized. If a strong enough r-f voltage is applied across these cones, the gap breaks down and forms an arc to short circuit the r-f voltage. However, the r-f voltage applied across the gap by an incoming target signal is much too low to cause such an arc. Therefore, during the receiving part of the cycle of operation, the T-R box acts simply as a tuned circuit (fig. 42) to transfer the echo signal from the r-f line to the crystal mixer and the receiving system. This tuned circuit presents the correct matched impedance to the received echo signal. Because of the high impedance presented by the line leading to the cold transmitting oscillator, practically all the echo signal passes into the line to the T-R box and is coupled effectively to the crystal mixer and receiving system.

c. Action During Transmission.

(*1*) During the transmitting part of the cycle the operation of the T-R box is completely different than during the receiving part. Refer to figure 42. As the outgoing pulse reaches the tee-junction, part of its energy goes up the branch line toward the receiver and reaches the T-R box. The voltage of this pulse is more than sufficient to break down the gap quickly in the T-R tube and form an arc across the gap

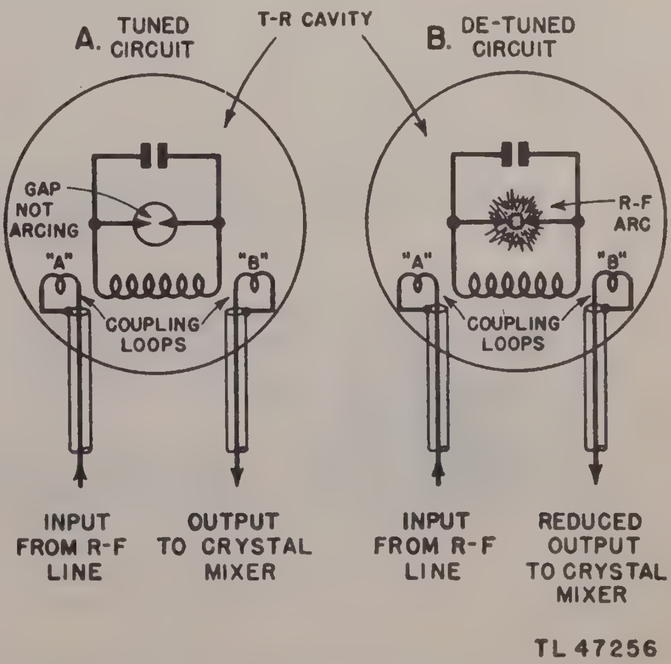


Figure 42. T-R box, equivalent circuit.

which effectively short-circuits the voltage and prevents damage to the crystal mixer. The arc continues for the entire duration of the transmitted pulse.

(*2*) The presence of this arc between the cones in the T-R tube produces two effects. First, it detunes completely the resonant circuit represented by the T-R cavity, which is then no longer an effective coupling medium between the r-f line and the receiving system. Second, the length of line from the tee-junction to the T-R box is a quarter-wave (or any odd multiple of a quarter-wave) so that the presence of a short circuit in the T-R box creates, for the r-f pulse at the tee-junction, an effective open circuit with high impedance looking toward the T-R box. This keeps out of the T-R box any more energy than is needed to keep the arc going; and the small portion of the transmitted pulse required to do this accounts for the appearance of the transmitted pulse signal on the screen of the range and PPI scopes. In this way, the crystal in the crystal mixer is protected from damage, and virtually the entire energy of the transmitted pulse passes down the main r-f line and is radiated from the antenna. At the end of the transmitted pulse, the r-f arc between the cones in the T-R tube goes out, and the cavity returns automatically to its tuned condition ready to accept the received echo signal.

SECTION V
ROTATING JOINTS

46. GENERAL.

As indicated in paragraph 34**d**, the function of the rotating joints is to allow the antenna and reflector to be turned in azimuth and tilted in elevation, and to allow the antenna to be spun at 1,800 rpm. These joints are relatively simple electrically but complicated mechanically because of the high precision required to maintain a constant separation between the stationary and rotating conductors and because the joints are required to be airtight to maintain the r-f line air pressure. A simplified diagram of the rotating joints is shown in figure 43. The rotating and fixed sections of the line are coupled by the action of a half-wave transformer. The inner conductors of the stationary and rotating parts of the r-f line overlap an electrical half-wave and are coupled as effectively as though they were actually connected to each other. Similarly the outer conductors of the stationary and rotating parts overlap and are effectively coupled. Because the coupling effectiveness of the joint depends on the half-wave transformer action, the overlap distance is critical at one-half wavelength. The electrical continuity of the line is thus maintained even without actual contact, and the joint is equivalent to a solid line section.

47. AZIMUTH AND ELEVATION LOW-SPEED JOINTS.

The locations of the azimuth and elevation low-speed joints is shown in figure 33, and a cut-away view of the low-speed joint is shown in figure 44.

a. Mechanical Operation. The accurate alignment of the two sections of outer conductor is accomplished by the use of needle roller bearings, while the two sections of the inner conductor are aligned by means of a pin and bearing socket. The joint is pressure sealed by rubber gaskets on both sides of the roller bearings, and since this joint operates at a low speed it is possible to use a number of gaskets packed tightly and still obtain satisfactory operation. On the forward, or antenna side of each joint, the inner conductor is supported by two straight-line stub supports, and at the rear, or transmitter end, by a single right-angle stub support. The coupling to the r-f line on both sides of the joint is made by means of a standard line coupling.

b. Electrical Operation. As indicated in paragraph 46, the rotating joint is constructed to use the impedance reflection property of a standing wave to make the electrical connection between the rotating and stationary sections of

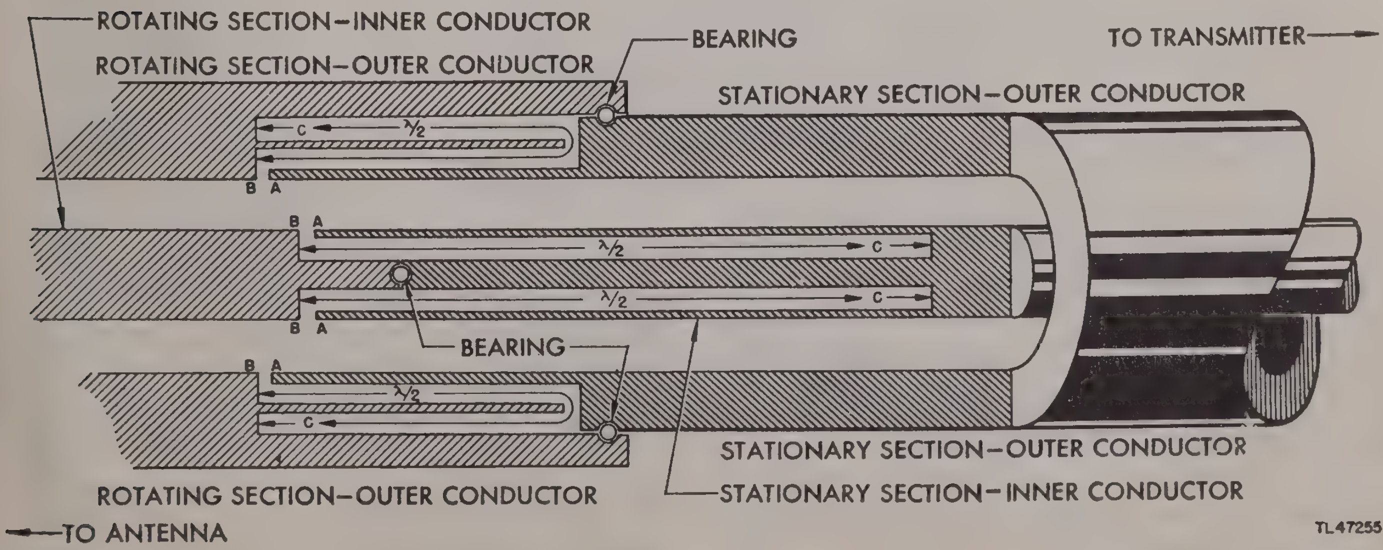


Figure 43. Rotating joint, simplified diagram.

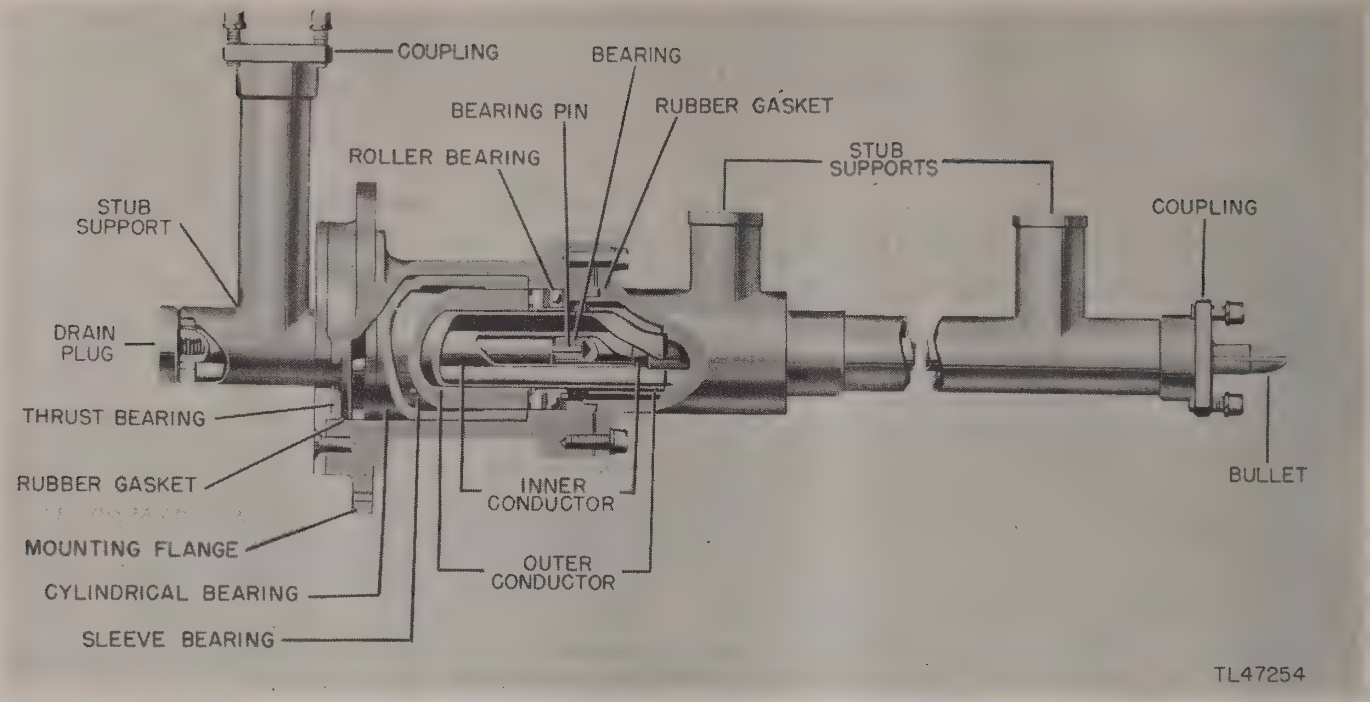


Figure 44. Low-speed rotating joint, phantom view.

the joint. Refer to figure 43. To apply r-f power through the joint and to the antenna it is necessary that the energy be coupled from point A to point B. Reliance on physical contact between points A and B would be unsatisfactory because the contact would be intermittent. To effect a smooth flow of r-f energy between points A and B it is necessary to have very low resistance. This low resistance is accomplished by using a half-wave section of line to create a standing wave which reflects to A and B a low resistance from some other point. Since a short is an ideal low resistance the line is so constructed that the points C are simply shorts and therefore low resistance points. The r-f energy of the line sets up standing waves in the cavity section between C and A and B. The line is so constructed that this electrical distance is one-half wavelength, which makes the standing wave one-half wavelength long, shorted at one end (point C). It is a property of a standing wave of this length that it reflects at the open end the same resistive impedance as exists at the shorted end. Since this resistance is practically zero, the resistance at A and B is zero and there is no impedance to the flow of r-f energy from point A to point B.

48. HIGH-SPEED ROTATING JOINT.

The location of the high-speed rotating joint is shown in figure 33, and a cut-away view of the high-speed joint is shown in figure 45. This joint extends through the center of the reflector, and carries the r-f transmission line from the rear of the reflector through to the antenna assembly in front of the reflector. The high-speed joint is in two sections (fig. 45) joined together by a short section of r-f line. When the high-speed joint is assembled in its proper place in the pedestal, this section of r-f line passes through the center of the housing that contains the reference generator and spinner motor. The rear section of the high-speed joint is partly inclosed in the housing of the reference generator and spinner motor.

a. Mechanical Operation.

(*1*) The outer conductors are kept in alignment by means of a set of ball bearings and a set of needle roller bearings. The inner conductors are kept in alignment by means of a pin and bearing socket as used in the low-speed joints. The rear end of the joint has its inner conductor supported by means of a right-angle stub of standard type (fig. 45).

(*2*) The part of the r-f line to the rear of the break at the joint remains stationary, while that part forward of the break takes on the 1,800-rpm rotation speed of the spinner motor.

(*3*) It is necessary to provide an airtight seal between the stationary and moving parts of the line and it is essential that this seal will run dry, and still not burn at the running speed. The seal is obtained by means of a pair of highly polished steel sealing rings, and a similarly smooth and flat ring of carbon (pressure ring) which rides between them. The steel ring in front of the

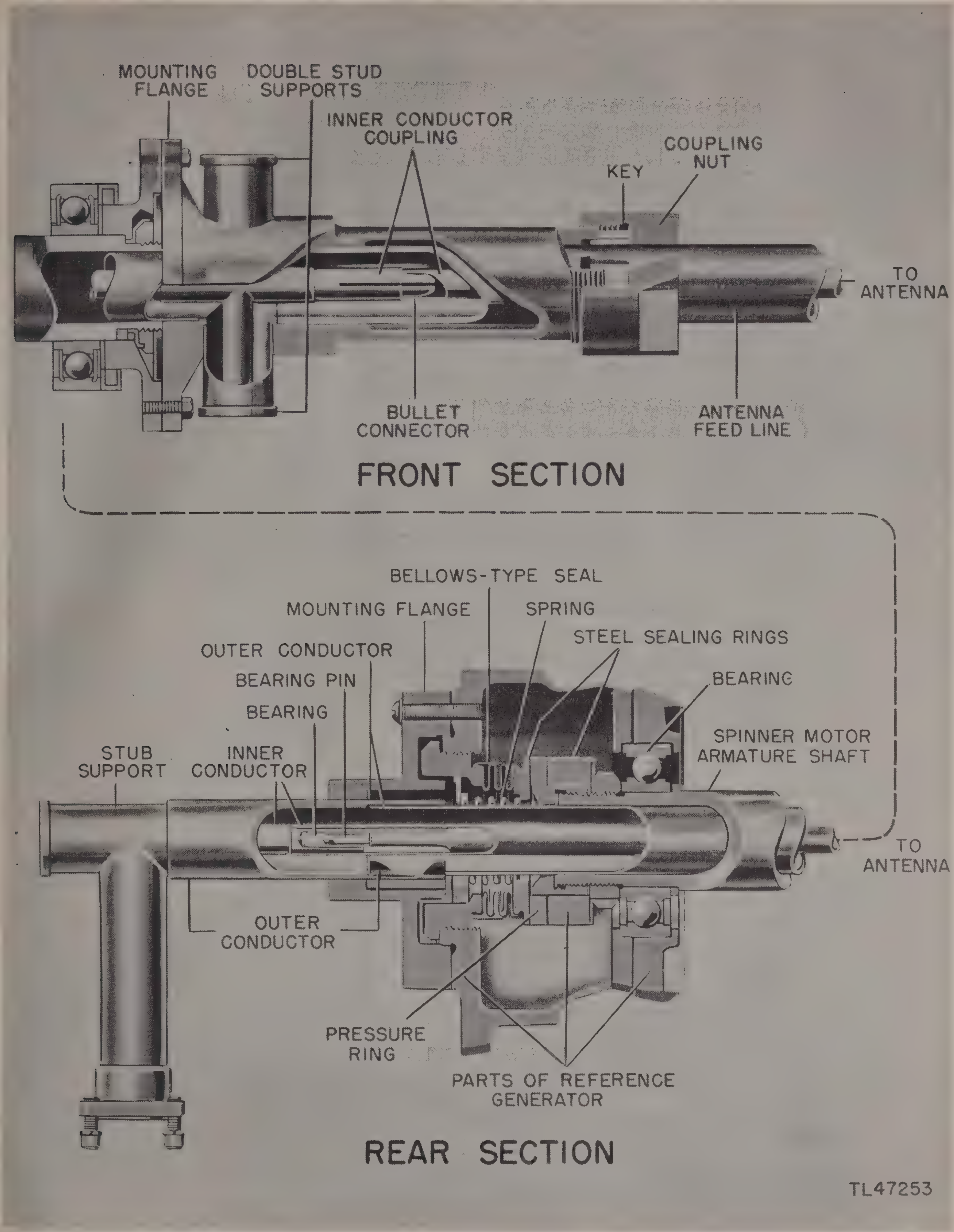


Figure 45. High-speed rotating joint, phantom view.

carbon ring turns with the armature of the spinner motor, while the steel ring behind the carbon ring is stationary and is itself the nose of a bellows type seal containing a spring. The flexible airtight bellows permits the spring to drive the steel nose ring into continuous tight contact with the carbon ring, allowing for lateral drift of the carbon ring or any wear in that ring, without losing the pressure seal.

(*4*) The forward section of the high-speed joint, together with the coupling union to the antenna feed line, is shown in figure 45. The inner conductor at the forward end of the joint is supported by two standard straight line stub supports, placed exactly opposite each other to balance the line mechanically. The union with the short section of line leading to the antenna is accomplished with a bullet connector and a large flanged nut.

b. Electrical Operation.

(*1*) The electrical operation of the high-speed rotating joint is similar to that of the azimuth and elevation low-speed joints in that it uses half-wave sections of line shorted at one end to produce a low resistance at the point where it is desired to couple the r-f energy from the stationary section to the rotating section of the line. A detailed explanation of this method of coupling is given in subparagraph 47**b**.

(*2*) The forward section of the high-speed rotating joint is equipped with a quarter-wave choke attached to the stationary housing of the spinner motor. This choke produces a short for any r-f energy that may leak back into the housing and prevents damage caused by r-f arcs within the bearing.

SECTION VI
ANTENNA AN-101-A

49. CONSTRUCTION.

Antenna AN-101-A is illustrated in figure 46. The part of the transmission line that is attached to the antenna is inserted into the open end of the forward section of the high-speed rotating joint, and positioned in the joint by means of a threaded locking nut. The transmission line then continues forward to the antenna proper which is inclosed in a plastic shell. Details of construction of the antenna are shown in figure 47.

a. The antenna dipole is in two halves which are soldered to the inner and outer conductors of the transmission line. One half of the dipole is soldered to the outer conductor; the other half passes through a large opening cut in the outer tubular conductor and is soldered to the inner conductor.

b. A quarter-wave tubular section having a diameter larger than the outer conductor surrounds the outer conductor of the transmission line and is connected to it at one end.

c. A short distance in front of the dipole is a small metal reflecting disk which is attached to the main transmission line.

d. Near the metal reflecting disk, the r-f line is closed and shorted by a copper plug which fills the space between the inner and outer conductors.

e. The inner conductor continues for a short distance beyond the copper plug and projects through the end plate of the plastic housing as a threaded hollow tube, which is then closed off by a screw cap. A hole is drilled through the small shorting plug which allows air to enter the inner conductor from the large space inside the plastic shell. When the r-f line is operated under pressure, the air inside the plastic housing is also under pressure. When the air bleeder screw cap is removed from the end of the inner conductor, the entire air content of the r-f line and the plastic housing may be exhausted through this opening.

50. OPERATION.

a. Quarter-wave Section (fig. 47). For maximum radiation efficiency the dipole antenna must be excited from a balanced line, but it can be fed from the unbalanced coaxial line if a means of exciting the outer conductor can be obtained. The transition cannot be made directly because the junction would present an interruption in the electrical characteristics of the line which would

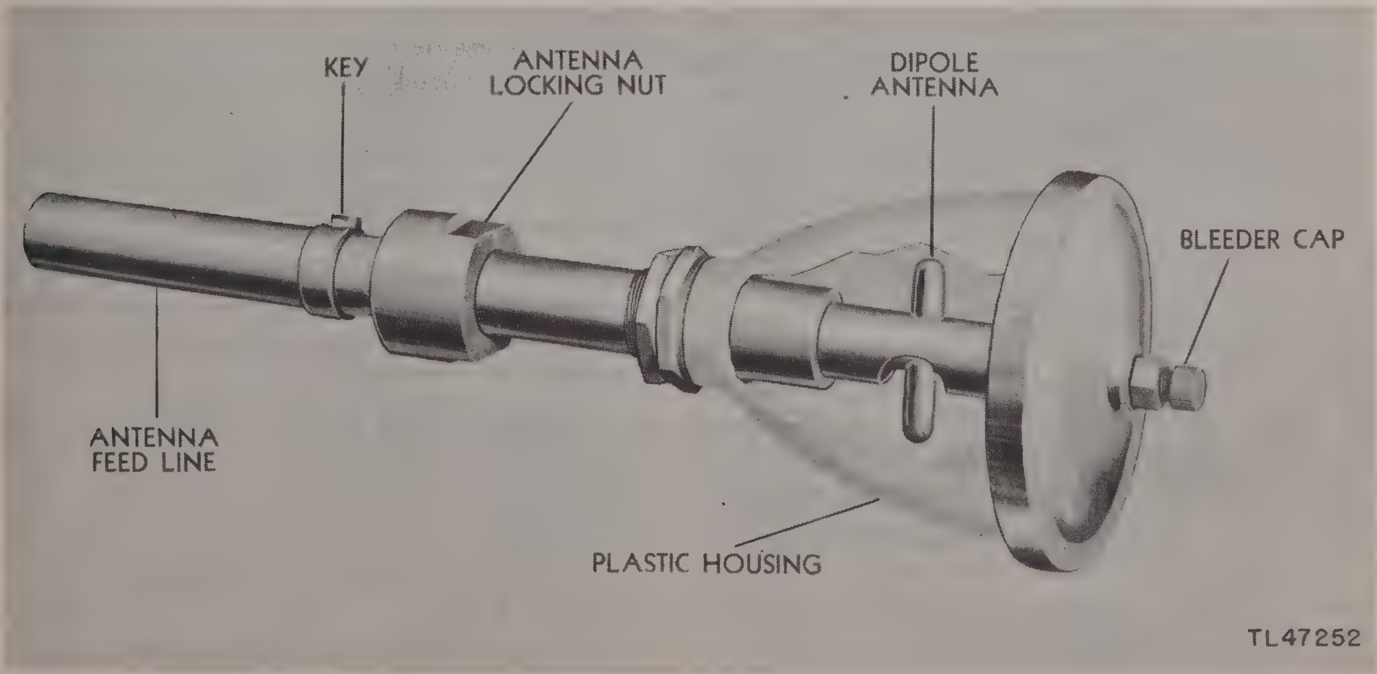


Figure 46. Antenna assembly.

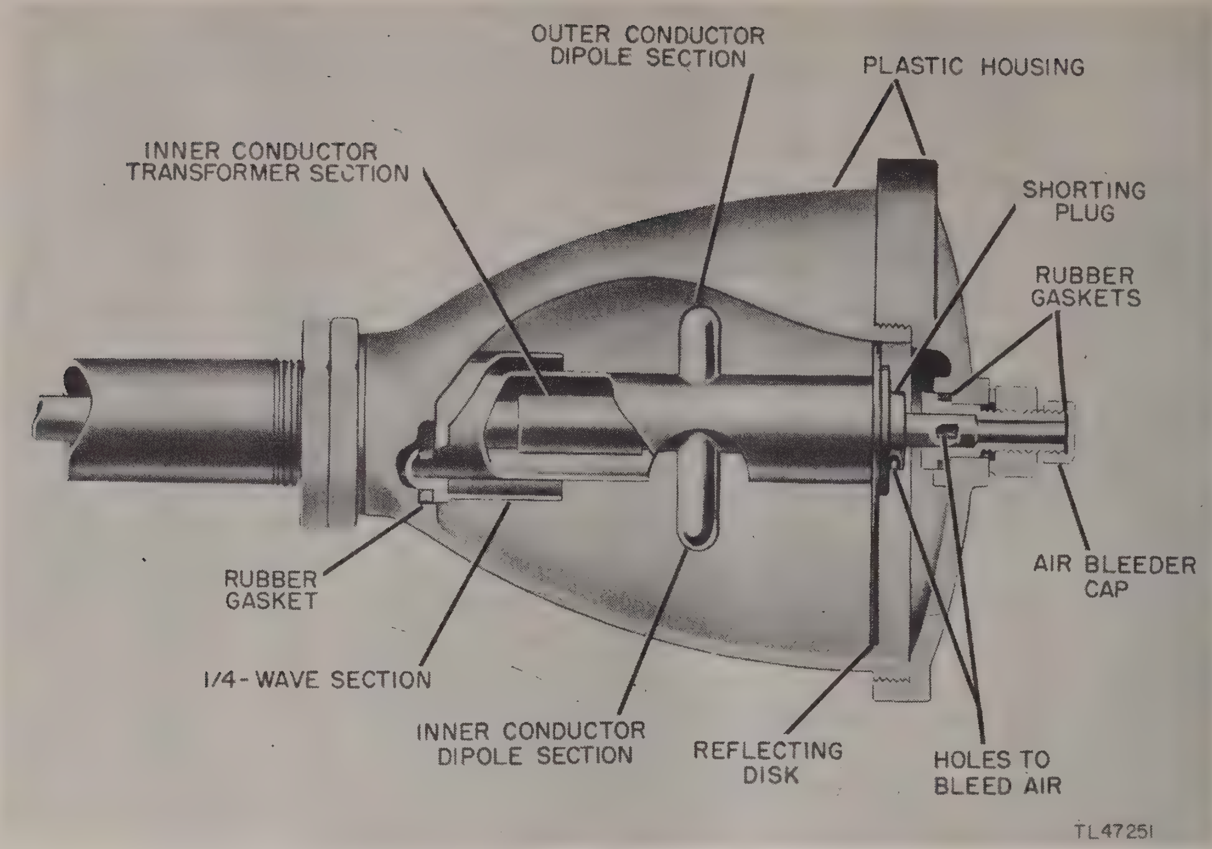


Figure 47. Antenna construction.

increase the standing-wave ratio and decrease the radiation efficiency. However, a junction can be made by using the quarter-wave section as a line-balance converter, or as it is commonly called, a bazooka. This section is connected to the grounded outer conductor of the coaxial line within the plastic housing and acts as a quarter-wave section of line shorted at one end, presenting a very high impedance at the open end. Remember that the dipole requires a push-pull voltage, yet it is being fed from a coaxial line whose outer conductor is grounded. By surrounding this outer conductor with the quarter-wave section and grounding the section to the transmission line at one end only, both halves of the dipole are made to receive a push-pull output. This action is explained as follows: At the open end of the quarter-wave section, a high impedance exists and allows an r-f voltage to appear on the outer conductor of the main transmission line. As the inner and outer conductors are shorted together at the reflecting disk, the same r-f potential exists on the inner and outer conductors, and they are in a balanced condition with respect to ground. Thus the dipole is fed from a balanced push-pull line. The high impedance at the open end of the bazooka isolates this r-f potential from the grounded outer conductor of the main line. Note that the entire outer conductor of the main transmission line is grounded except the section between the open end of the quarter-wave section and the outer end of the line within the plastic housing.

b. Shorting Plug. The transmission line extends beyond the dipole for a short distance and is then shorted by a metal shorting plug (fig. 47). This short length of transmission line between the dipole and the plug constitutes a stub. This stub is similar in action to a quarter-wave stub in that its length is such that the energy reflected at the short, presents an impedance at the dipole. Thus the dipole does not see the plug as a short, but instead sees the correct value of impedance at the point where it is connected to the transmission line.

c. Reflecting Disk (fig. 47). The reflecting disk is soldered to the shorting plug at the end of the coaxial line. The reflecting disk sends most of the forward radiated energy back into the main reflector (sometimes called the parabola) where it is focused to strengthen and narrow the beam. If it were not for this reflecting disk, about half the energy radiated from the dipole would travel directly out from the dipole in a

very broad beam. This same type of reflecting disk is used in the case of a searchlight beam to make certain that all the light which leaves the searchlight has been focused into a narrow beam by the reflector.

d. Transformer Section (fig. 47). That part of the inner conductor designated as the transformer section in figure 47 is used to match the transmission line to the dipole. This transformer makes certain that there is an efficient transfer of energy between the line and the dipole. It is similar to the transformers used in connection with the stubs, which support the inner conductor of the transmission line, and functions in the same way as an ordinary quarter-wave transformer. An increase in the diameter of the inner conductor decreases the impedance of the line.

e. Offset Beam. The beam produced by the antenna and reflector does not lie along the axis of the reflector because of the slightly unbalanced construction of the dipole. Actually one-half of the dipole is longer than the other half (fig. 47). A description of the offset beam produced is given in paragraphs 52 **b** and **c**.

51. POLAR DIAGRAM.

In describing how Radio Set SCR-784 operates, it is necessary to discuss in some detail the beam which is produced, the manner in which the beam is offset from the axis of the reflector, and the ways in which the rotation of the beam makes automatic tracking possible. Refer to figure 48.

a. It is assumed that at origin O there is a reflector and dipole similar to those used in this set. This reflector arrangement focuses the energy radiated by the dipole into a narrow beam in the direction indicated by the axis of the reflector. The insert in figure 48 shows the reflector at O and the dipole near the focus of the reflector.

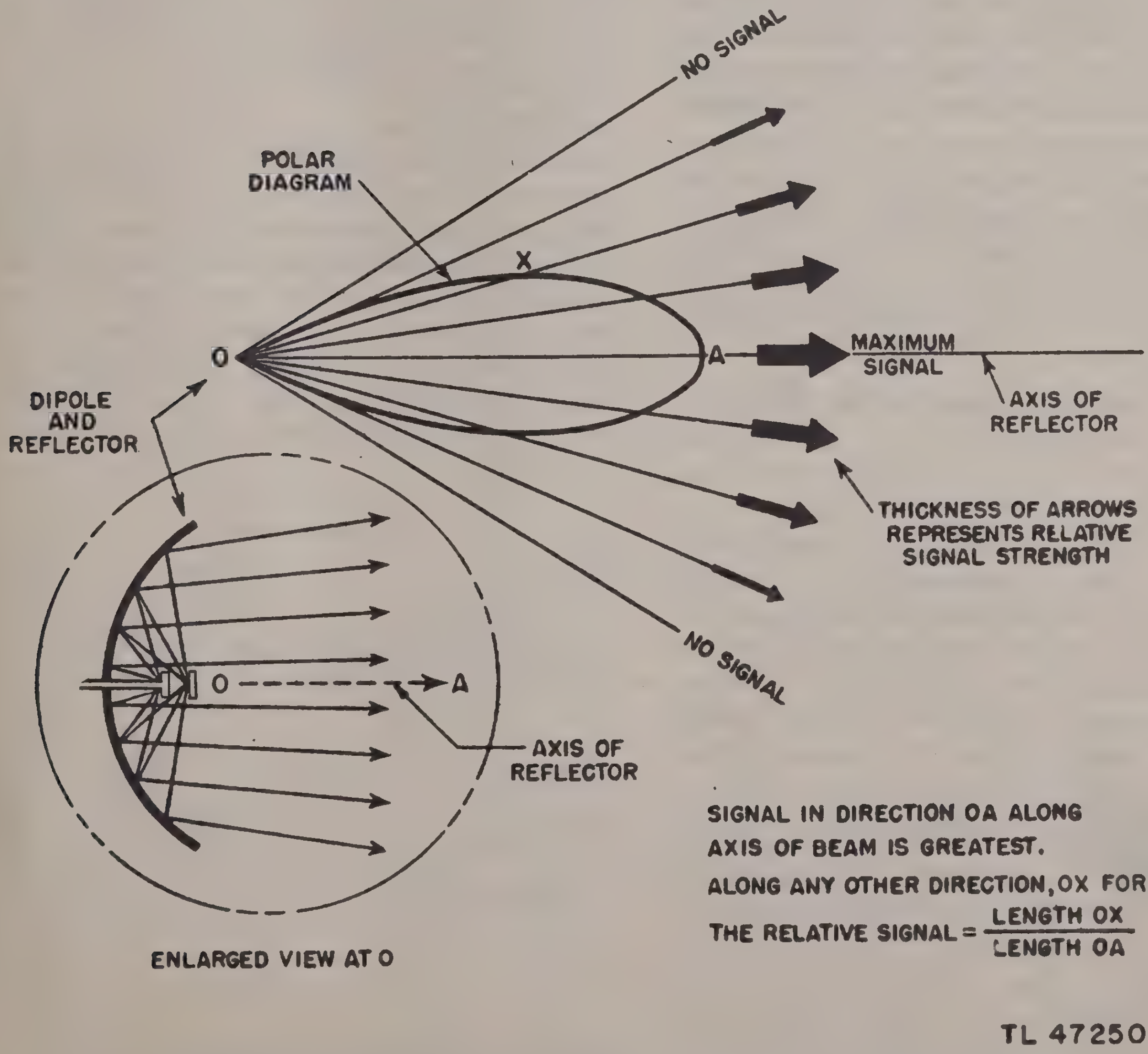


Figure 48. Use of a polar diagram to represent a beam of radio waves.

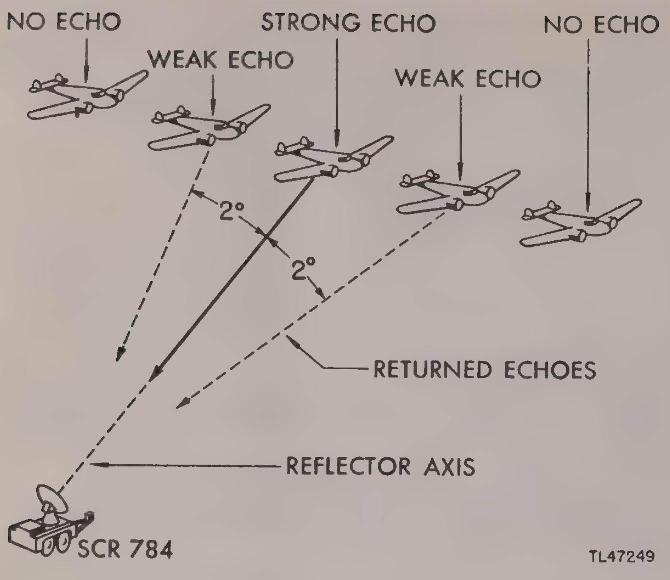


Figure 49. Effective beam width.

b. The heavy arrows shown around the circumference of the circular trace with O as the center, are used to indicate the relative signal strength radiated in various directions. These are the signal strengths which would be observed if an airplane carrying a signal-strength meter were to fly a circular course with O as the center and make a record of the strength of the pulses received from O. Along the axis of the beam, the arrows appear very heavy because most of the energy of the beam is along the axis. Near the outer edges of the beam, however, the arrows become faint because the signal becomes correspondingly weak.

c. The information regarding the directivity of a beam, which is represented by the varying thicknesses of arrows, can be shown more conveniently by means of a curve called a polar diagram. The relative strength of a beam in any direction can thus be measured. If the strength of the beam in the direction OX is required, a line is drawn from O in the required direction and the distance from O to the point X on the curve is measured. If OX, for example, is half of OA, then this means that the beam is half as strong in the direction OX as it is in the direction OA. The same principle applies for any other direction. Note that toward the edge of the beam where the arrows thin out to zero width, the polar diagram curve returns to the origin, indicating that the intensity is zero. The simple polar diagram shown in figure 48 is often referred to as a lobe. During the discussion on conical scanning and automatic tracking it is convenient to refer to the lobe rotating as the antenna rotates.

d. Do not confuse the oval shaped curve of the polar diagram in figure 48 with the exact shape of the beam. The polar diagram represents only the shape of the beam indirectly in that it shows the relative signal strength in any desired direction.

52. BEAM OF RADIO SET SCR-784.

a. Beam Width. In the case of Radio Set SCR-784, the beam produced is approximately 4 degrees wide. The meaning of a 4-degree beam is made clear in figure 49 which shows how the signal received at the set is affected by the angle which the target makes with the axis of the beam. When a target is lined up with the axis of the beam, the maximum signal is returned to the SCR-784. When the target is outside of the beam, that is, more than 2 degrees either side of the axis, a very weak signal is received. As the line of the target approaches the line of the beam, the echo returned to Radio Set SCR-784 increases to a maximum.

b. Offset Beam.

(*1*) The polar diagram of the beam produced by Radio Set SCR-784 is shown in figure 50. A noticeable feature of this beam is that the direction of maximum radiation is not the same as the direction of the axis of the reflector. The axis of the beam is offset slightly, about 1¼ degrees from the axis of the reflector, the axis of the reflector pointing always, of course, in the direction indicated by the azimuth and

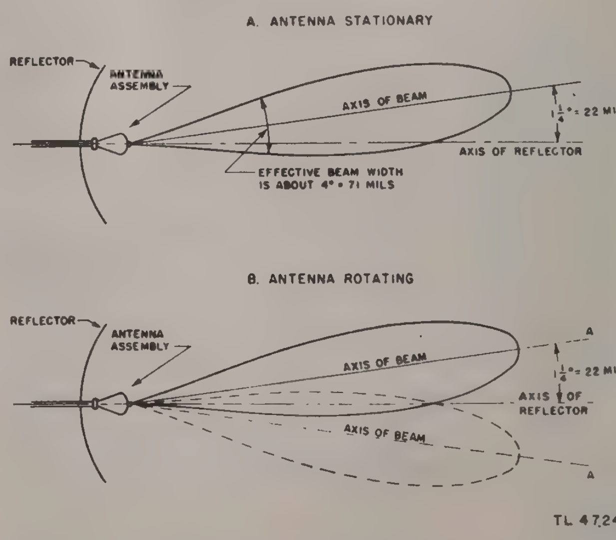


Figure 50. Offset beam, antenna stationary, and antenna rotating.

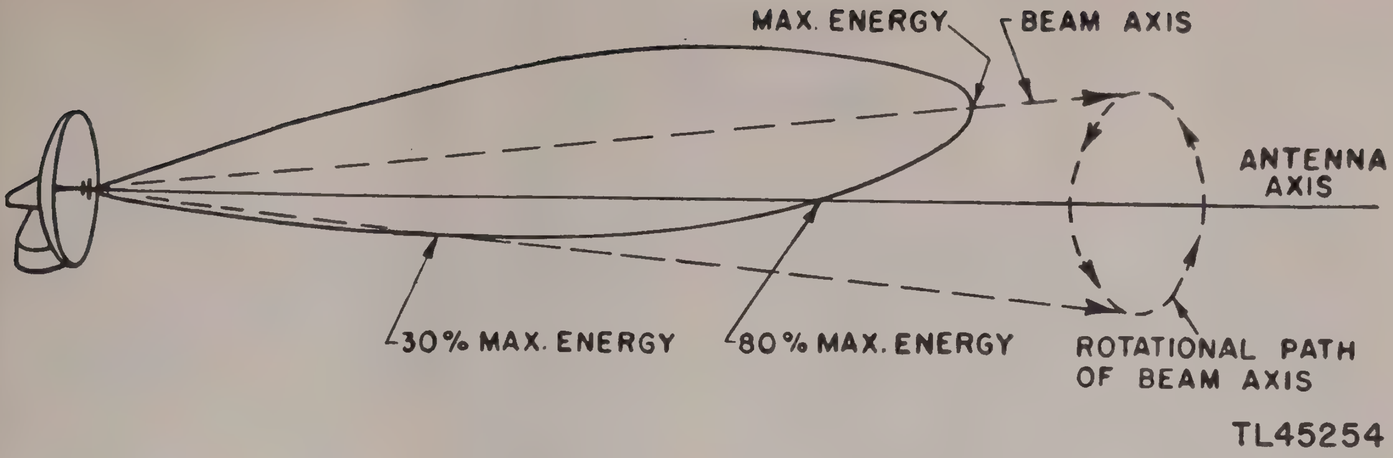


Figure 51. Antenna beam, illustrating conical scanning.

elevation dials. The beam is intentionally offset in this manner so that rotation of the antenna can be used to explore the space in the vicinity of the target and provide sufficient information regarding the position of the target to enable automatic tracking.

(*2*) Electrically, the beam is offset because the two halves of the dipole are not symmetrical, one half of the dipole being slightly longer than the other, as shown in figure 47. Because of this, the radiation from one half is greater than the radiation from the other, with the net result that the radiation into the reflector does not originate on the axis of the reflector. The beam is thus thrown to one side as shown in figure 50. The amount the beam is offset is approximately 1¼ degrees or 22 mils.

c. Rotation of Beam. When the antenna is rotated, the axis of rotation is along the axis of the parabolic reflector, but since the beam makes an angle of approximately 1¼ degrees with that axis, the axis of the beam describes a long narrow cone around the axis of the reflector. Figure 51 illustrates this condition. The conical scanning resulting from this rotation of the beam develops a continuous echo signal of varying strength from the target, the signal strength at any one instant depending on the position of the beam at that instant. This tendency of the echo signal to vary in relation to its conical position is used to enable the set to track the desired target automatically.

SECTION VII
DEHYDRATOR

53. GENERAL.

The concentric r-f line of Radio Set SCR-784 is designed to operate under an air pressure of 3 to 5 pounds per square inch. The proper operation of the r-f system depends upon keeping the inside of the transmission line and rotating joints as clean and dry as possible. Excessive moisture may result in r-f arcs at various points along the line, which would seriously interfere with the transmission of energy and change the characteristics of the supporting stubs. The dehydrator (fig. 52) serves to keep the air in the line dry and maintains the 3- to 5-pound air pressure.

54. DESCRIPTION.

The dehydrator is inclosed in a perforated metal case and all the controls for operating the unit are located on the front panel (fig. 52). A 1/4-inch pipe leads from the dehydrator to the r-f line where the line leaves the local oscillator compartment.

55. CYCLE OF OPERATION.

The dehydrator consists of two identical units connected together through a system of electrically operated valves. When one unit is being used to remove moisture from the r-f line, the other unit is being dried; so it can replace the first unit when it has become saturated with moisture. The operating cycle is shown most clearly by considering: first, when the dehydrator is delivering dry air continuously to a badly leaking transmission line; second, when the dehydrator is delivering dry air to a transmission line that is reasonably free from leaks. The flow diagram in figure 53 together with the schematic circuit diagram in figure 54 show the relative positions of the component parts of the dehydrator and the electrical switching mechanism that distributes the flow of electricity through the various circuits. The valves are shown in figure 53 in the position they take during the first half cycle of operation. The numbers in the following discussion refer to the part numbers in the above mentioned flow diagram.

a. Cycle for Badly Leaking Transmission Line. When the transmission line is leaking badly, air is taken in by the compressor (1) and delivered through the open line valve (2) and the finned tube (3) into the dehydrating cell (4). In the dehydrating cell (4) the air gives up its moisture to the active silica gel. The dry air then passes out through the air filter (7), the air check valve (8), the humidity indicator (10) and into the transmission line.

(*1*) *Reactivation Period.* During the first 2 hours and 40 minutes that the air flows as outlined above, the left reactivation valve (22) is open and the heater (18) is turned on. The heat from the heater drives all the moisture out of the silica gel contained in the dehydrating cell (17). The moisture, in the form of steam, passes out through the air filter (20) and the open reactivation valve (22). This period is called the reactivation period since it is during this time that the dehydrating cells are restored to their active state.

(*2*) *Purge Period.* At the end of the reactivation period, the purge valve (12) opens and allows some of the air from the compressor to pass through the purge orifice (13), finned tubing (16), dehydrating cell (17), air filter (20), reactivation valve (22), and out into the atmos-

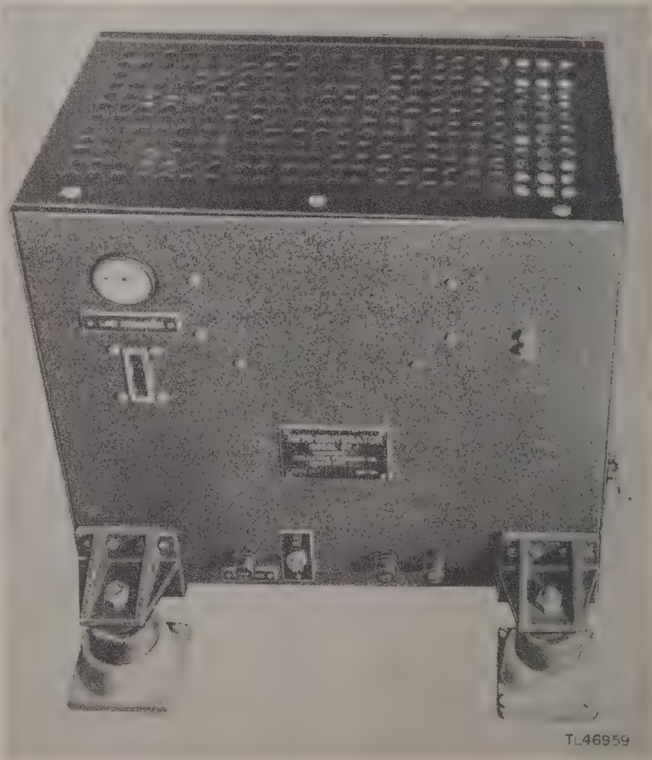
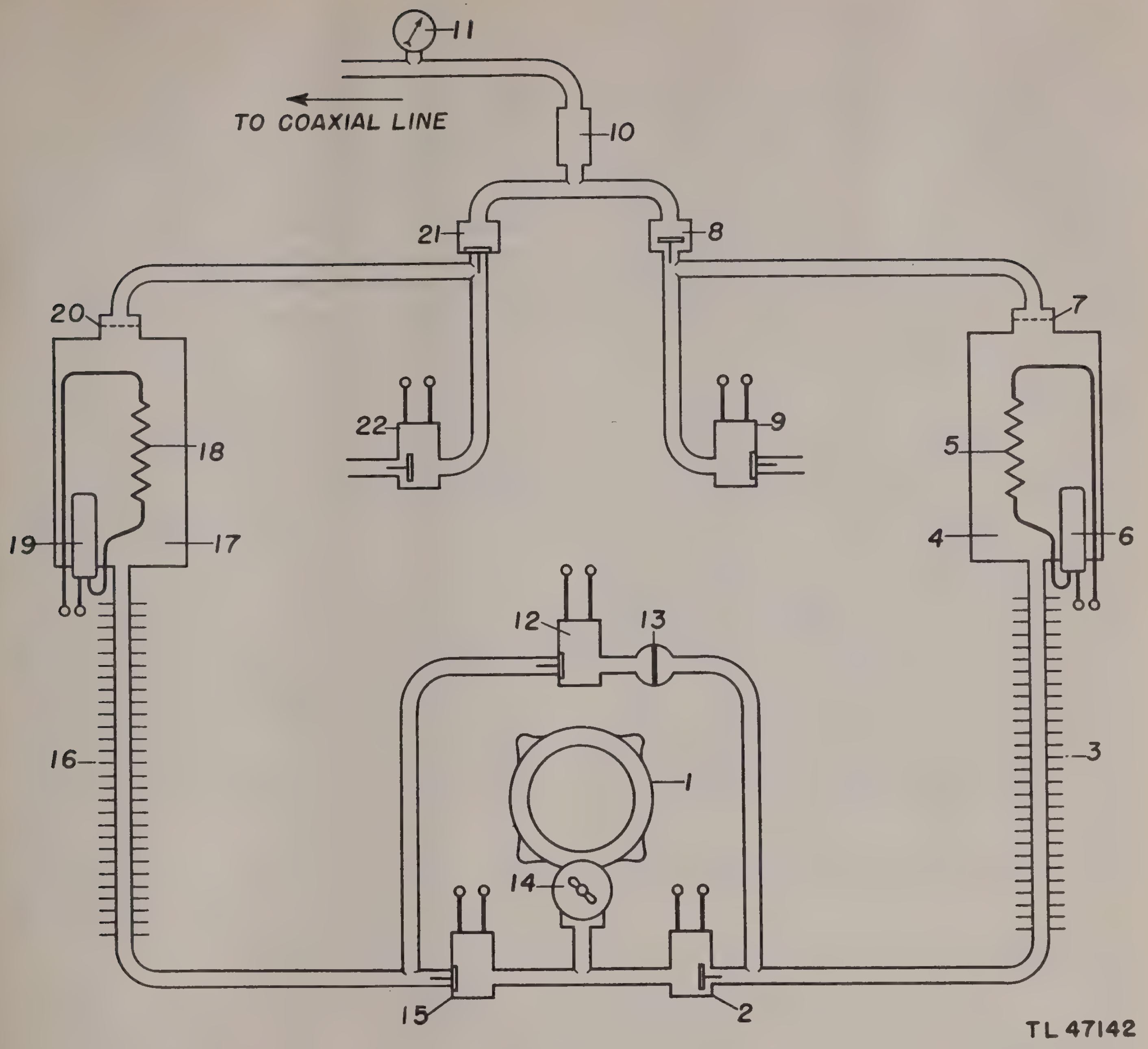


Figure 52. Dehydrator, front panel.



NUMERICAL LEGEND

1	Compressor.	12	Purge valve.
2	Right line valve.	13	Purge orifice.
3	Right finned tube.	14	Pressure switch.
4	Right dehydrating cell.	15	Left line valve.
5	Right heater.	16	Left finned tube.
6	Right thermo-switch.	17	Left dehydrating cell.
7	Right air filter.	18	Left heater.
8	Right check valve.	19	Left thermo-switch.
9	Right reactivation valve	20	Left air filter.
10	Humidity indicator.	21	Left check valve.
11	Pressure gauge.	22	Left reactivation valve.

Figure 53. Dehydrator, flow diagram.

phere. The purge valve (12) is held open about 20 minutes, long enough to purge the system of any moisture that may have condensed on the tubing walls or in the valves.

(3) *Cooling Period.* At the end of the purge period, the purge valve (12) and the reactivation valve (22) close and the heater (18) shuts off. The air continues to flow through the dehydrating cell (4) for a period of 3 hours, just the same as it did during the reactivation period. During this 3-hour period, the dehydrating cell (17) cools to room temperature. This period marks the end of the first half of the dehydrating cycle.

(4) *Second Half of Cycle.* At the start of the second half of the dehydrating cycle, line

valve (2) closes, line valve (15) opens, reactivation valve (9) opens and the heater (5) turns on. Atmospheric air is now pumped through the active dehydrating cell (17) while the moisture previously absorbed by the dehydrating cell (4) is being driven off. The second half of the cycle is identical with the first except that the dehydrating cell (4) is now the inactive cell. The reactivation period, purge period, and cooling period follow in the same order as during the first half cycle; thus the complete dehydrating cycle requires 12 hours.

b. Cycle for Transmission Line Reasonably Free of Leaks.

(*1*) *Reactivation Period.* When the transmission line is reasonably free from leaks, air is taken in by the compressor (1) and delivered to the transmission line through the line valve (2), finned tube (3), dehydrating cell (4), air filter (7), check valve (8) and humidity indicator (10). The compressor operates until the pressure in the transmission line reaches the cut-out pressure of the pressure switch (14). When the pressure switch cuts out, it shuts off the compressor motor only. The program timer motor operates continuously during the reactivation period and the purge period. Therefore, regardless of the line pressure, the heater (18) is on and the reactivation valve (22) is open constantly during the 2 hours and 40 minutes of the reactivation period.

(*2*) *Purge Period.*

(*a*) *Beginning of Period.* At the beginning of the purge period, the purge valve (12) opens and allows air to escape from the dehydrating cell (4) through the purge orifice (13), purge valve (12), finned tube (16), dehydrating cell (17), air filter (20), and reactivation valve (22) out to the atmosphere. The escape of air through the purge orifice (13) causes the pressure in the dehydrating cell (4) to drop, the pressure switch (14) cuts in, and the compressor starts. The orifice (13) is of such size that the compressor can build up only to 8 pounds pressure when the purge valve is open. Therefore, if the pressure switch is set to cut out below 8 pounds, then the compressor runs intermittently during the purge period, and if the pressure switch is set to cut out above 8 pounds then the compressor runs continuously during the purge period.

(*b*) *End of Period.* At the end of the purge period the heater (18) turns off, reactivation valve (22) and purge valve (12) close, and the contact colored yellow in the program timer opens and places the timer motor under the control of the pressure switch (14). The compressor and the timer now run only when the line pressure drops below the cut-out pressure of the pressure switch (14). Therefore the 3-hour cooling period may stretch out over a

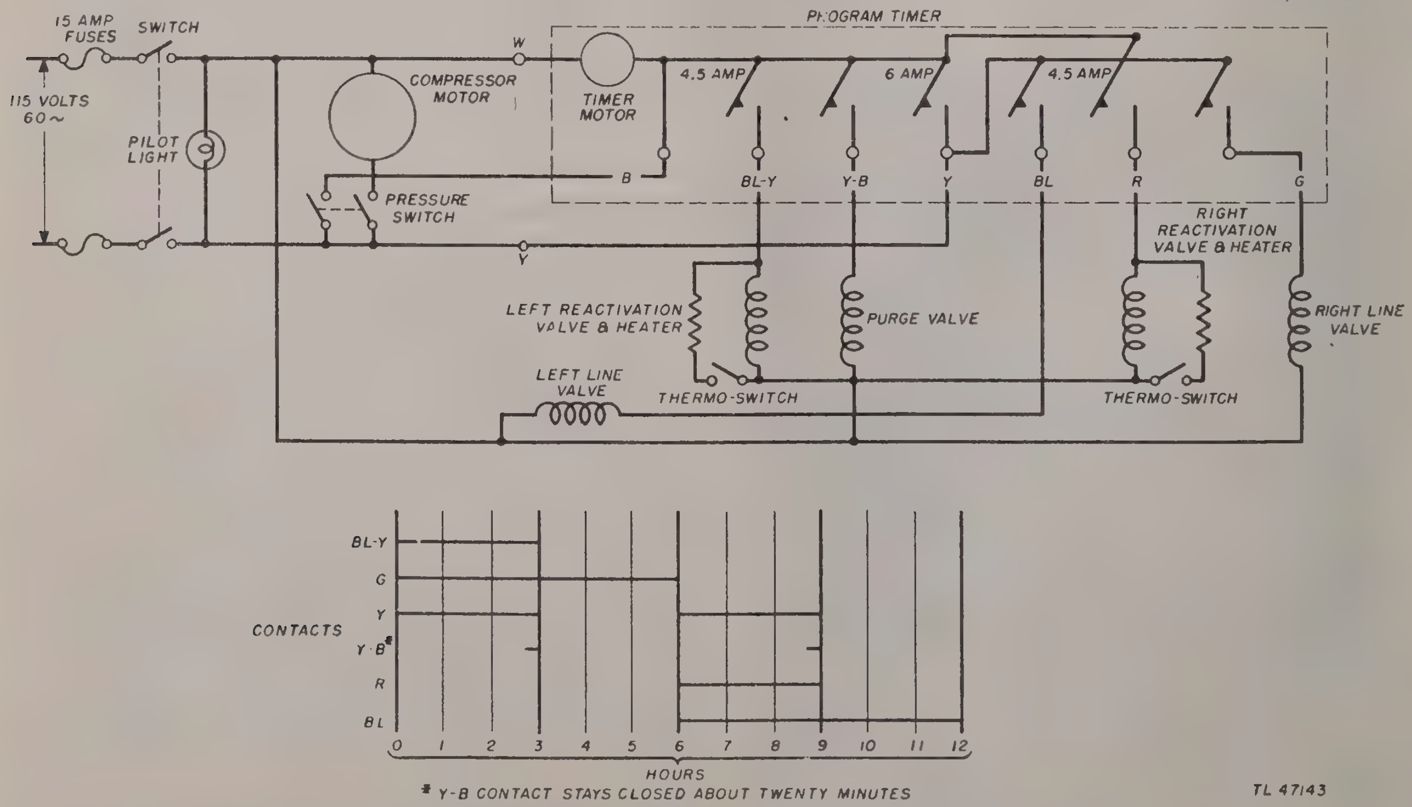


Figure 54. Dehydrator, schematic circuit diagram and time chart.

period of days depending upon the size of the leak in the transmission line.

(3) *Second Half of Cycle.* After the timer motor has actually run for 6 full hours, including the reactivation period, the purge period, and the cooling period, line valve (2) closes, line valve (15) and reactivation valve (9) open, and the heater (5) turns on. This starts the second half of the cycle which carries on exactly as outlined above except that during this half of the cycle, the dehydrating cell (17) becomes the active cell and the dehydrating cell (4) becomes the inactive cell.

56. PROGRAM TIMER.

a. The program timer consists of a series of switches which open and close at certain desired times by cams attached to a rotating shaft. The shaft rotates one full revolution in 12 hours. A schematic diagram showing the electrical circuit of the dehydrator is given in figure 54. This figure also includes a time chart which indicates the open or closed position of the switches.

b. The cams are so set that during the first 3 hours the blue-yellow, the green, and the yellow contacts are closed. The blue-yellow contact opens the left reactivation valve (22) and closes the left heater circuit (18), the green contact opens the right line valve (2), and the yellow contact closes the timer motor circuit so that the pressure switch has no control over it. In addition the cams close the yellow-black contact during the last 20 minutes of the first 3 hours and therefore open the purge valve (12). At the end of 3 hours the blue-yellow, yellow, and yellow-black contacts open. The green contact stays closed for the next 3 hours of operation of the timer motor.

c. At the end of 6 hours the cams open the green contact and close the yellow, red, and blue contacts. During this time the timer motor again does not react to the opening and closing of the pressure switch but is in continuous operation. The red contact opens the right reactivation valve (9) and closes the right heater circuit (5), and the blue contact opens the left line valve (15). At the end of 9 hours the yellow, yellow-black, and red contacts open but the cams allow the blue contact to remain closed for another 3 hours. At the end of 12 hours, the cycle is complete and again the blue-yellow, green and yellow contacts are closed by the cams to begin a new cycle.

CHAPTER 4
RECEIVING SYSTEM

SECTION I
INTRODUCTION

57. SIMPLIFIED BLOCK DIAGRAM (fig. 55).

The receiving system of Radio Set SCR-784 is designed to amplify the received target echoes and distribute them to the various control circuits. This is done by converting the echo signals to a lower frequency, amplifying and detecting them, further amplifying them, and distributing them to the proper control circuits. Basically the system is composed of six main components (fig. 55). The local oscillator is a velocity-modulated tube, producing a continuous high-frequency output. The crystal mixer combines the returned echo signal with the output of the local oscillator, and produces a lower (i-f) frequency that may be more easily amplified and detected. This i-f signal is fed to the preamplifier for amplification. The preamplifier is located close to the crystal mixer to reduce to minimum the attenuation of the signal in the cable coupling between the mixer and the preamplifier. The amplified i-f signal is fed to the receiver where it is further amplified in the i-f stages; then divided and fed to the servo channel and the range channel. In the servo channel the signal is detected and the video output further amplified and applied to the automatic tracking unit. The operation of this channel is controlled by the narrow gate from the range unit or by the N^2 gate from the ART unit, so that only signals within the gate are amplified. In the range channel the signal is fed to the remote video amplifier where it is detected and the video signal further amplified. The output of the range channel is applied to the range and PPI scopes to give a visual indication of the target's position, and to the ART unit to control the position of the range scope hairlines. Power for the local oscillator is furnished by a separate local-oscillator power supply, and power for the other system components is furnished by the regulated and the unregulated receiver power supplies.

58. COMPLETE BLOCK DIAGRAM (fig. 56).

In the complete block diagram of the receiving system (fig. 56), each stage of the system is represented and the directions of the signal and control voltages are indicated by arrows.

a. Local Oscillator. The local oscillator is a klystron tube producing continuous oscillation

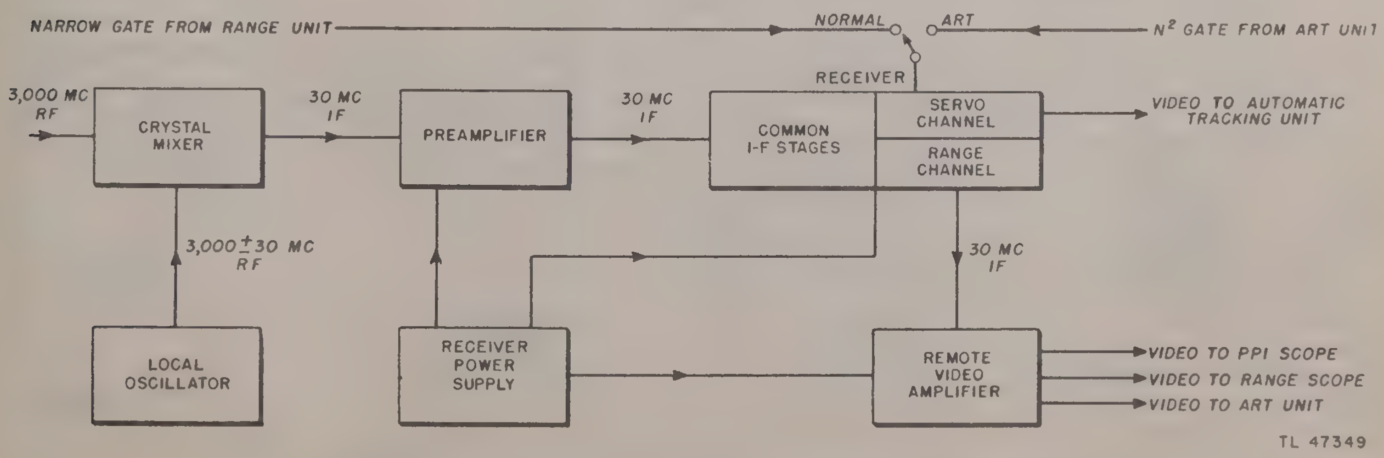


Figure 55. Receiving system, simplified block diagram.

which is either 30 mc higher or 30 mc lower than the transmitter frequency in order to produce the desired i-f frequency. The wavelength of the klystron output can be varied from 8.8 to 10.7 cm which more than covers the band of transmitter frequencies.

b. Crystal Mixer. The function of the crystal mixer is similar to that of the first detector or mixer in an ordinary superheterodyne receiver. The mixer combines the echo signal with the signal of the local oscillator to produce the i-f frequency. The conversion of the high r-f signal to a lower i-f signal of 30 megacycles enables the amplification of the weak echo signals to the level required for proper presentation and for control of various circuits.

c. Preamplifier. The preamplifier is a two-stage i-f amplifier located as close to the crystal mixer as possible. It amplifies the echo signal so it will not be lost in the cable to the receiver. Thus, this amplifier increases the over-all signal-to-noise ratio of the receiving system.

d. 3d, 4th, and 5th, I-f Stages. The 3d, 4th, and 5th i-f stages are located in the receiver chassis and further amplify the received signal from the preamplifier. The output of the 5th stage is divided and fed to the servo channel and the range channel.

e. Servo Channel. The 6th and 7th i-f stages further amplify the received signal. The 6th i-f stage also acts as a switch to allow the signal to be passed on to the automatic tracking unit when gated at the proper time by the narrow gate from the range unit or by the N^2 gate from the automatic range tracking unit. This servo channel responds only to the signal selected by the operator, and this channel operates only during the gate. The i-f signal is detected in the video detector and the video signal developed is fed to the video amplifiers. The two video amplifier stages amplify the video signal to the level required for control of the automatic tracking unit. A separate output is also fed to the AGC circuit which controls the gain of the 2d and 3d i-f stages.

f. Range Channel. The 6th and 7th i-f stages are similar to the 6th and 7th i-f stages in the servo channel, and perform the same function of amplifying the signal from the 5th i-f stage. Only the 6th i-f is located in the receiver chassis, the remaining stages of the range channel being mounted in the remote video amplifier located in the field power supply chassis. In the range channel on the field power supply chassis, the 30-mc input from the 7th i-f stage is rectified and the video signal developed is fed to the video amplifiers. The video amplifiers raise the

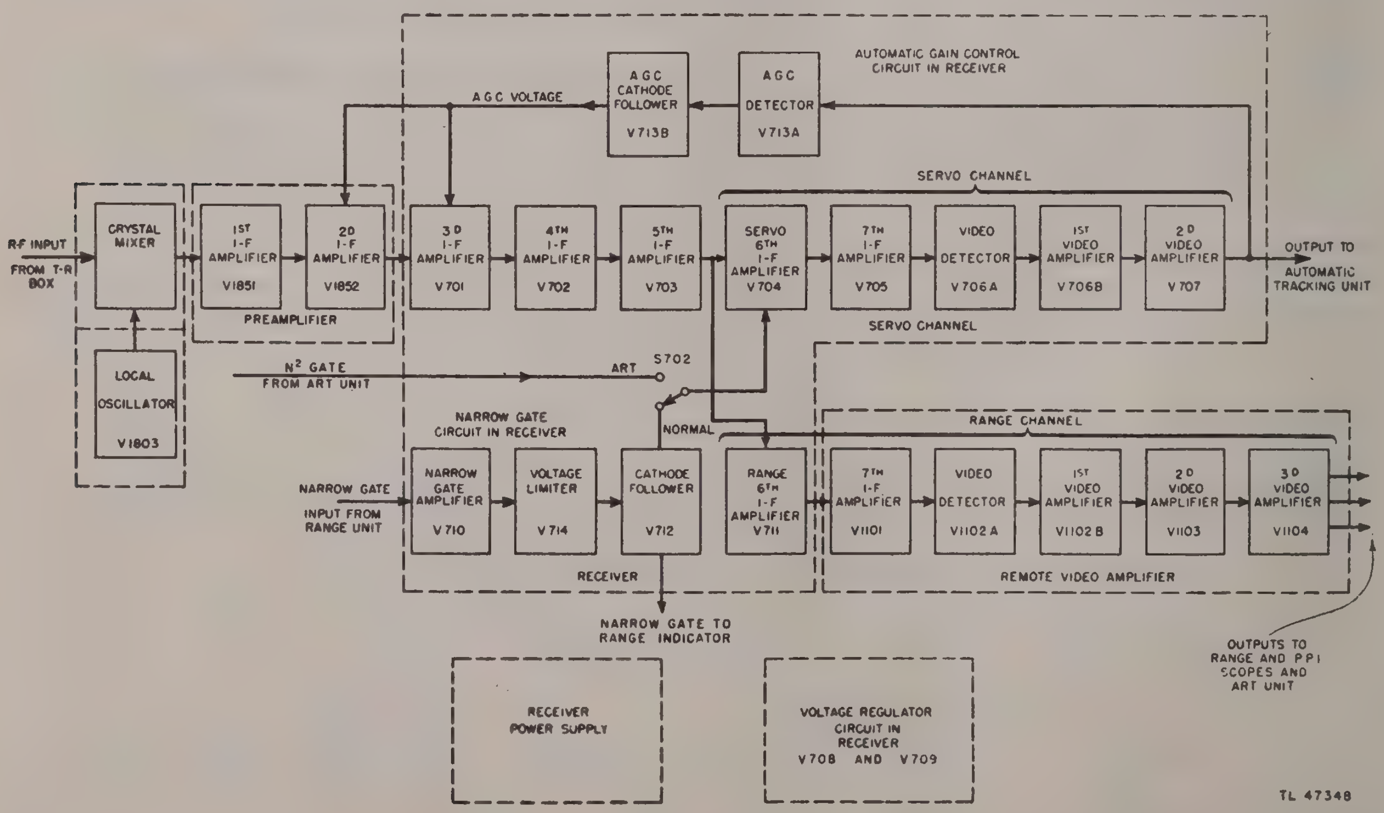


Figure 56. Receiving system, complete block diagram.

video signals to the proper amplitude for the range and PPI scopes and provide a video signal for the automatic range tracking unit (ART). There is one more stage of video amplification than in the servo channel to compensate for attenuation of the signal in the cables connecting the remote video amplifier.

g. AGC Circuit. The AGC circuit rectifies the signal from the servo channel and applies this rectified voltage as a control bias on the 2d and 3d i-f stages. This bias voltage keeps the gated video output of the receiver at a constant average-voltage level.

h. Narrow-gate Channel. In the narrow-gate channel the narrow-gate pulse from the range unit is amplified and limited and applied as a gate to the 6th i-f stage. The pulse is fed to the narrow-gate amplifier which increases its amplitude, then it is limited in the diode voltage limiter. The limiter determines the peak positive-voltage level of the output of the narrow-gate cathode follower. The output of the cathode-follower stage is a positive voltage pulse used as a gate to allow the 6th i-f servo stage to amplify the i-f signal for the duration of the pulse. The position of switch S702 determines whether this narrow-gate channel output or the output of the automatic range tracking unit (which is a 50-yard wide pulse) is used to gate the servo channel.

i. Receiver Power Supply. The receiver power supply contains two separate units: the unregulated plus 300-volt supply, and the regulated minus 105-volt supply. This power supply furnishes all of the operating voltages for the receiver, preamplifier, and remote video amplifier. Part of the plus 300-volt supply is reduced to plus 120 volts by the voltage regulator circuit in the receiver chassis.

59. CABLING (fig. 57).

The receiving system has an elaborate cabling system to connect the various receiving system components which are distributed about the trailer. The cables within the transmitter frame assembly are not numbered. They are connected to the receiving system components as shown in figure 57. The local oscillator controls and the AGC-relay-operating switch are brought to the indicator-control panel through cables No. 74 and No. 34. The N² gate and narrow gate are brought into the receiver through jacks J709 and J703. The use of the narrow-gate output from J704 is discussed in chapter 5, range system.

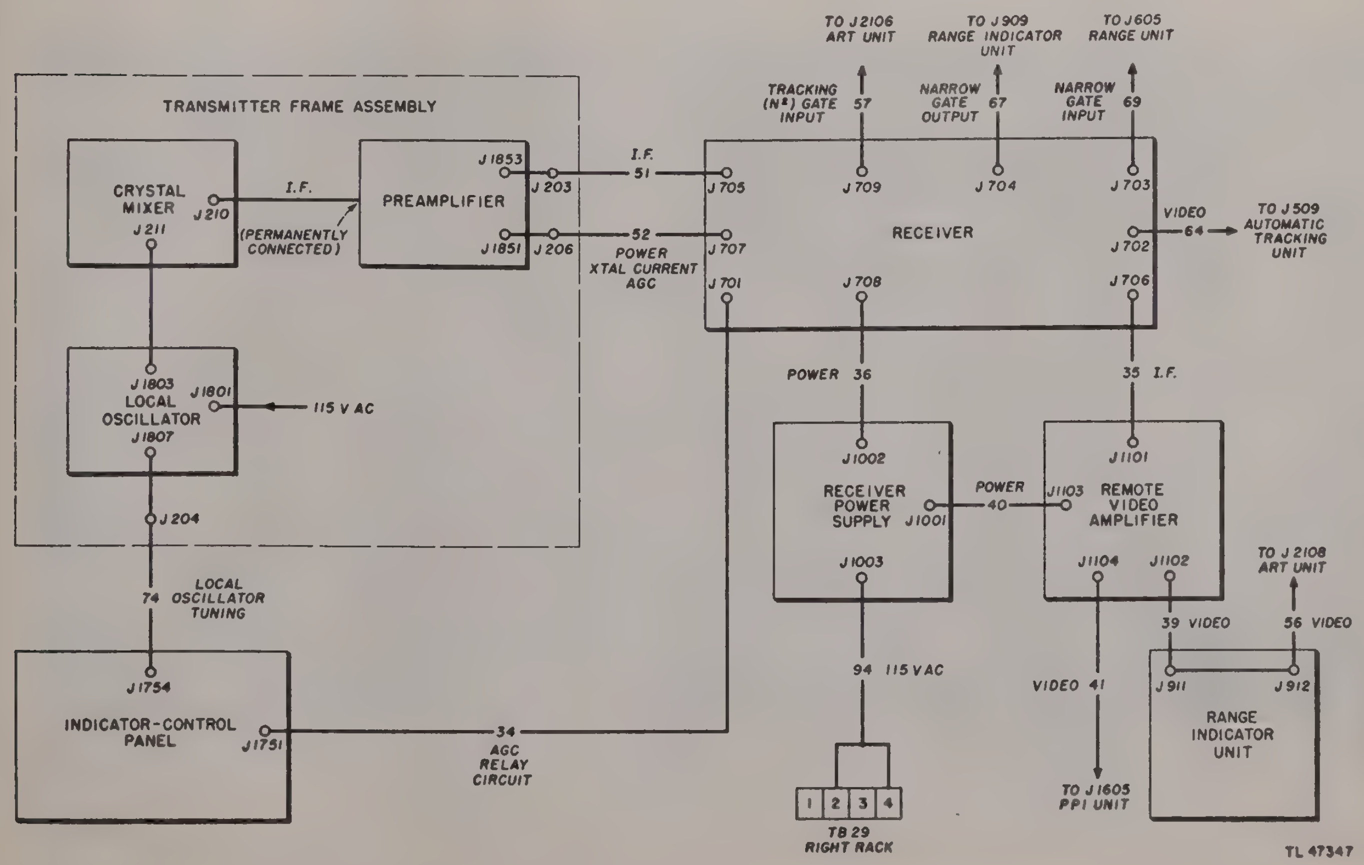


Figure 57. Receiving system, cabling diagram.

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SECTION II
LOCAL OSCILLATOR

60. INTRODUCTION.

The local-oscillator chassis (fig. 58) contains the local-oscillator tube with its power supply and the preamplifier. The chassis is located in the top center of the transmitter frame assembly. The local oscillator (fig. 59) is a special tube known as the reflex klystron, used because the high frequency (approximately 3,000 mc) at which the tube operates cannot be produced by an ordinary vacuum-tube oscillator. The power supply is specially designed for stable operation. A tuning motor is used to keep the local oscillator at the correct frequency by remote control from the indicator-control panel.

61. CONSTRUCTION OF REFLEX KLYSTRON.

a. A cross-section diagram of the type 417 klystron is shown in figure 60. The tube contains an indirectly-heated cathode; a control grid; a resonant cavity (formed by two metal flanges and a flexible corrugated metal diaphragm); two cavity grids; and a reflector plate. It fits a standard octal socket, but only four pins are used. The reflector-plate terminal is a standard ⅜-inch grid cap, located on top of the tube. Two coupling loops inserted in the cavity inductively pick up the energy of the oscillations. One loop couples the energy through a flexible shielded coaxial cable and jack J1803 to the crystal mixer. The other loop is connected to test jack J1804 on the front panel. This jack is used in checking the frequency of the klystron and is normally disconnected since it affects the operation of the klystron.

b. The two metal flanges are held together by three springs and are driven apart by three screws spaced around the resonant cavity. The flexible metal diaphragm connects the flanges and allows the motion to occur. A lever arm attached to one of the flanges is moved by a cam attached to the shaft of the tuning motor. The tuning motor rotates the cam causing a rocking motion of one of the flanges. This motion may be as much as $^1/_{32}$ of an inch. In addition to this motion the tuning motor itself can be moved

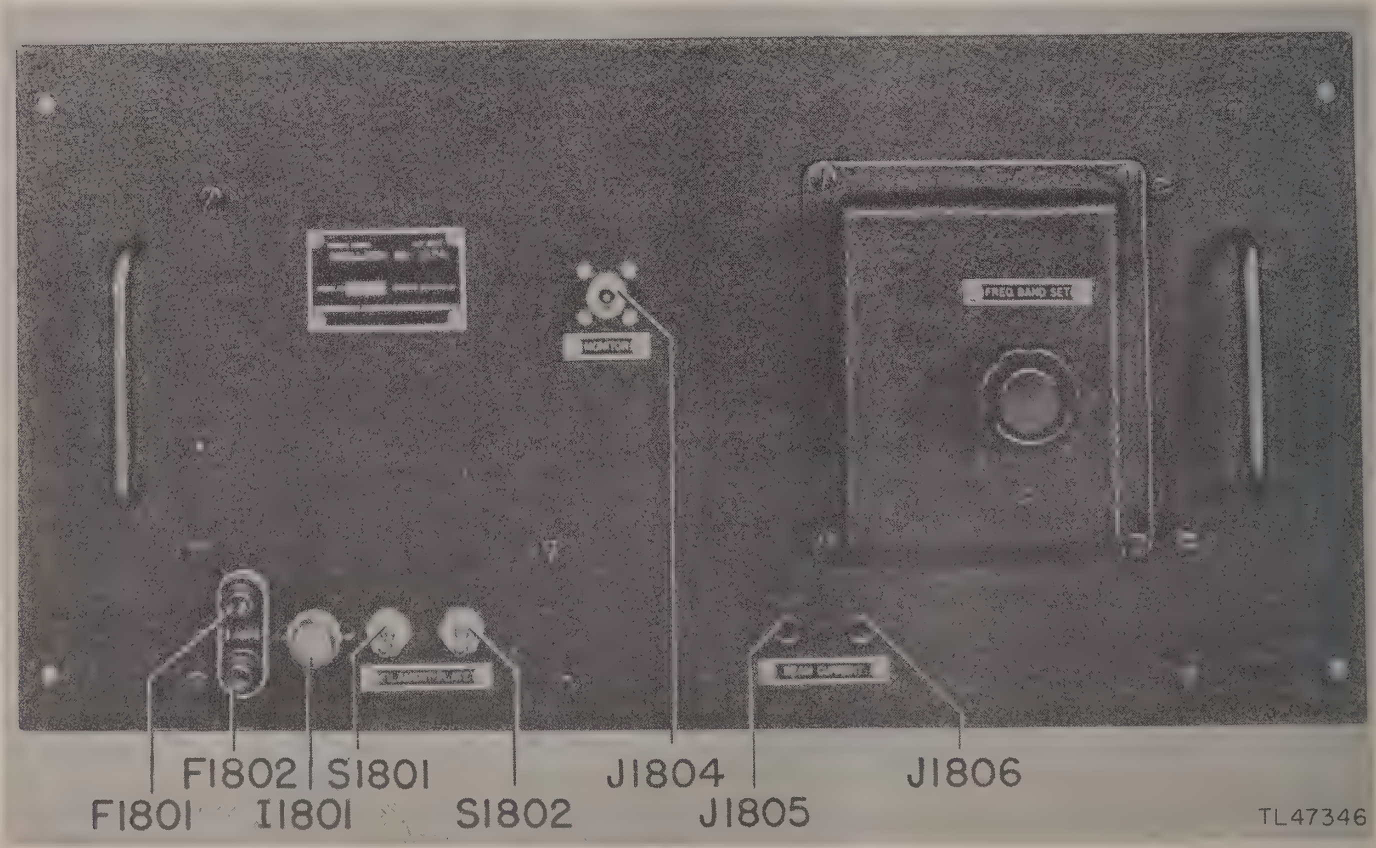

Figure 58. Local-oscillator chassis, front view.

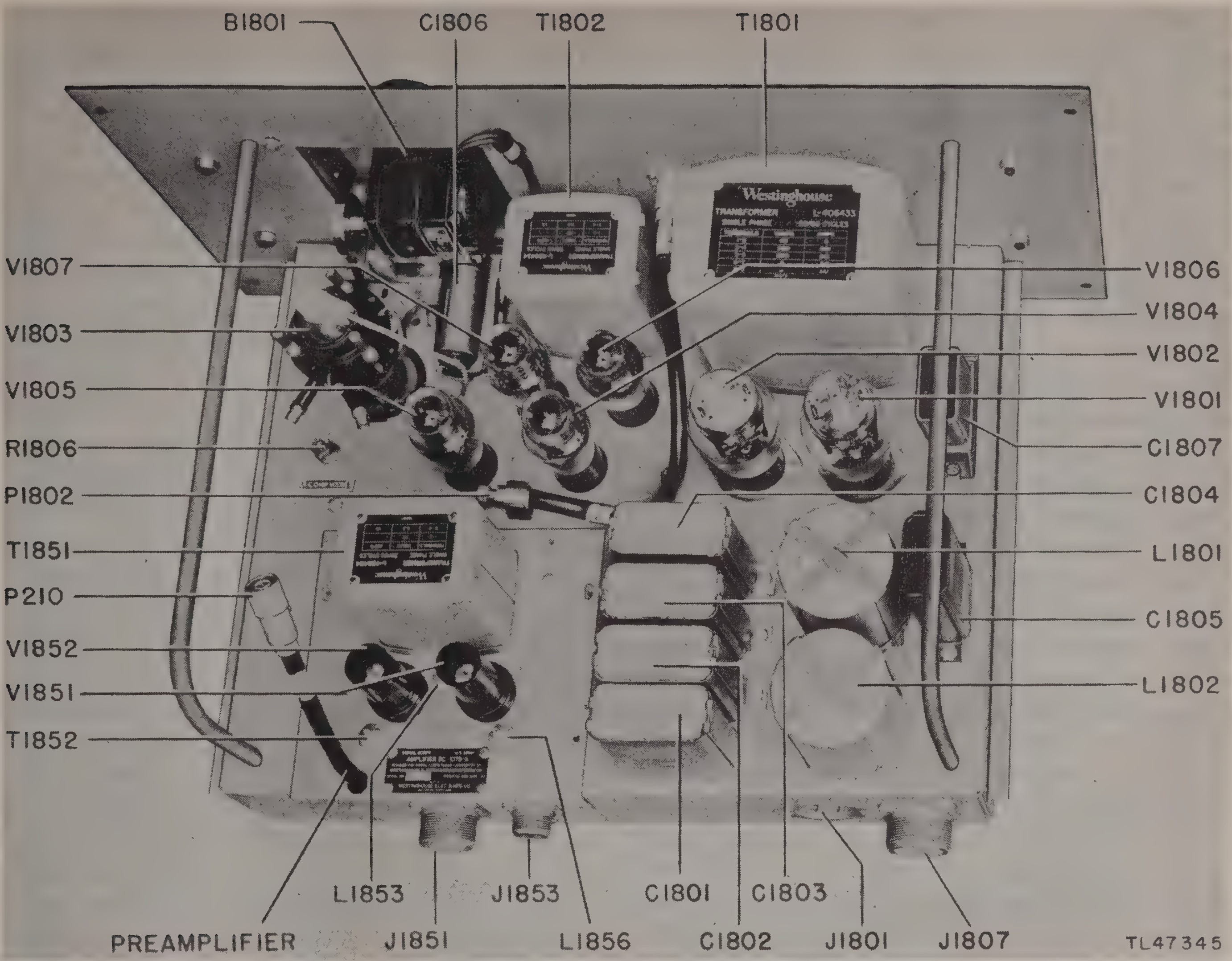

Figure 59. Local oscillator chassis, top view.

up and down against the lever arm giving greater swing to the rocking motion.

62. OPERATION OF REFLEX KLYSTRON.

The reflex klystron is a velocity-modulated tube. Its operation depends upon the modulation (or change in speed) of electrons passing through its cavity.

a. The electrons emitted from the heated cathode are attracted toward the accelerating grid. Although the accelerating grid is at ground potential, it is positive in respect to the cathode because the cathode is at minus 575 volts. The spacing of the wires of the two cavity grids permits most of the electrons to pass through them toward the reflector plate. However, the negative 575 to 785 volts on the reflector plate slows them up, repels the electrons, and sends them back through the cavity grids on a return trip. Thus the electron beam passes through the cavity grids twice.

b. When the electron beam approaches the first cavity grid A (fig. 60), the negative charge of the electrons induces a positive charge on the grid which sets up a weak oscillation in the cavity. This first weak oscillation charges grids A and B (fig. 60) alternately positive and negative, and a changing electric field between the grids is presented to the electron beam. The electrons that pass between the two grids

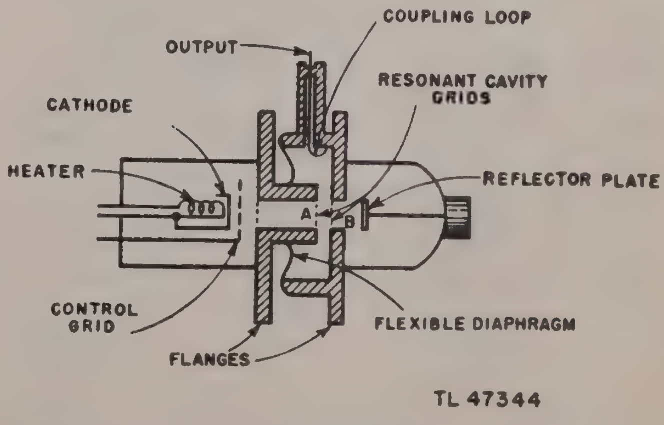

Figure 60. Local oscillator, cross-section view.

at the instant that the electric field between grids A and B is passing through zero, travel at the same constant velocity because there is no repulsion or attraction force upon them. Electrons passing between the grids when grid A is more negative than grid B leave with accelerated velocity because the positive field speeds them up. Electrons passing through the grids when grid A is more positive than grid B are slowed down. Therefore the electrons are alternately retarded and speeded every half cycle. Because of the differences in velocities of the electrons, at a point in space between the second grid and the reflector plate the beam is no longer a steady stream of electrons but consists of bunches of electrons spaced at regular intervals. With the proper operating potential on the reflector plate, these bunches are turned back and pass through the cavity grids for the second time. With the proper timing, the bunches of electrons arrive at the grids when the field between the grids is such that it opposes the movement of the electron bunches, thus slowing the electron bunches, delivering energy to the circuit, and reinforcing the original weak oscillation.

c. For sustained oscillations more energy must be delivered to the circuit than is absorbed and the electrons must return to the cavity at the proper time to reinforce the oscillation. This requires critical tuning adjustments.

63. TUNING.

Whether or not the oscillations are reinforced and maintained depends upon the size and shape of the cavity, the spacing between the cavity grids, and the voltages applied to the electrodes of the tube. Both electrical and mechanical tuning are done together but for clarity and simplicity are discussed separately.

a. Mechanical Tuning. The resonant frequency of the cavity, and therefore the frequency of the local oscillator, is varied by changing the size of the cavity itself and the space between the cavity grids. In electrical terms this corresponds to varying the effective capacitance and inductance of the resonant circuit formed by the cavity.

(*1*) Coarse tuning is accomplished by varying the distance between the two metal flanges, which in turn varies the spacing between the grids. The tuning range with this coarse tuning adjustment is between 3,400 and 2,800 megacycles. To increase the local oscillator frequency, the distance between the flanges is increased, which decreases the capacitances between the two cavity grids. This action of increasing the distance between the flanges also increases the volume of the cavity at the same time, which tends to decrease the local-oscillator frequency, but the effect is very small in comparison to the effect of decreasing the capacitance between the cavity grids. Tuning over the entire frequency range results in a severe strain on the flexible diaphragm and may rupture it. It should not be necessary to tune over this range more than 3 times during the life of the tube.

NOTE: This coarse tuning adjustment should be made only when the tuning motor will not adjust the klystron to the desired frequency range.

(*2*) Fine tuning over a 27-megacycle range is accomplished by rocking one flange with respect to the other. This is done by the cam on the shaft of the tuning motor. The switch on the indicator-control panel controls the direction of rotation of the motor. The motor body and the cam can be moved by a knob on the front of the local oscillator chassis to further vary the rocking motion of the flange and the local oscillator frequency.

b. Electrical Tuning. Even with proper spacing of the cavity and cavity grids, the tube may not oscillate. The proper voltage relationship must exist between the cathode, control grid, and reflector plate. The GRID VOLTS control (R1817) mounted on the local oscillator chassis and the REFLECTOR VOLTS control (R1751) mounted on the front of the indicator-control

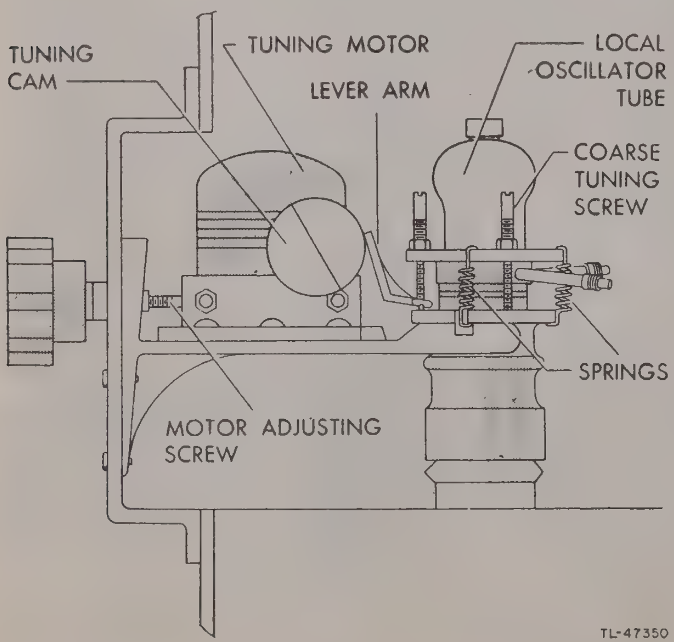

Figure 61. Local oscillator, mechanical details.

panel are used to adjust the accelerating grid and the reflector plate to the proper operating potentials. Actually the tube will oscillate for several different combinations of these potentials. The GRID VOLTS control is used to adjust the beam current and is set for a normal value of 20 ma as measured between jacks J1805 and J1806 located on the front panel of the local-oscillator chassis. The REFLECTOR VOLTS control is adjusted for maximum crystal current as indicated by meter M701 on the receiver panel. The REFLECTOR VOLTS control is the more critical adjustment of the two. If two separate settings of the REFLECTOR VOLTS control cause oscillations, the most clockwise setting is used. When the local oscillator goes into oscillation, the beam current increases. At the same time, the reading of the CRYSTAL CURRENT meter rises sharply because this milliammeter measures the rectified current produced through the crystal mixer. The CRYSTAL CURRENT meter is a convenient indication of whether or not the klystron is oscillating and of its relative output. The normal reading of the meter is between 0.15 and 0.5 milliampere. Because of thermal expansion of the resonant cavity, the klystron frequency may drift several megacycles while warming up during the first 10 or 15 minutes of operation. After this, under normal conditions, the tube should not drift in frequency more than 300 kilocycles (0.01% of its operating frequency).

64. OPERATING CHARACTERISTICS.

The operating characteristics of the klystron local oscillator are as follows:

- Available tuning range......8.8 to 10.7 cm wavelength (2,800 to 3,400 mc).
- Cathode voltage....... –570 to –600 volts.
- Control-grid voltage...... 10 to 20 volts above cathode.
- Cavity voltage....................ground.
- Reflector voltage...... 0 to 210 volts below cathode.
- Beam current..............20 milliamperes.
- Control-grid current.....3 to 5 milliamperes.
- Heater voltage..6.3 volts a-c (tied to cathode).
- Heater current.................1.3 amperes.
- Power output...........20 to 60 milliwatts.

65. LOCAL OSCILLATOR POWER SUPPLY.

a. The local oscillator power supply uses two conventional half-wave rectifier tubes V1801 and V1802. Figure 62 is a simplified schematic and figure 79 is a complete schematic showing the circuits of this power supply. The filtered output provides the d-c voltages for the cathode, control grid, and reflector plate of the klystron. Switch S1801 applies a-c power to the primary of the klystron filament transformer T1802. Switch S1802 applies a-c power to the primary of transformer T1801. These switches, located on the front panel of the power supply, are labeled FILAMENT and PLATE respectively.

(*1*) The output of tube V1801, developed across the resistor network R1811 to R1817 and R1826, provides the required negative voltages for the operation of the klystron. Resistor R1826 is tied to ground; so all of the tapped-off voltages applied to the klystron are negative with respect to ground. The output of rectifier V1801 is unregulated. It furnishes approximately —575 volts to the cathode of the klystron. Potentiometer R1817, the GRID VOLTS screwdriver adjustment located on top of the chassis, is used to keep the control grid 10 to 15 volts more positive than the cathode.

(*2*) The output of rectifier V1802 is regulated by the four VR-105-30 voltage regulators. A portion of the fixed voltage drop developed across these four regulator tubes is selected by the setting of the REFLECTOR VOLTS control (R1751) located on the indicator-control panel. This regulated output is connected through potentiometer R1806 to the unregulated supply. The voltage applied to the reflector plate

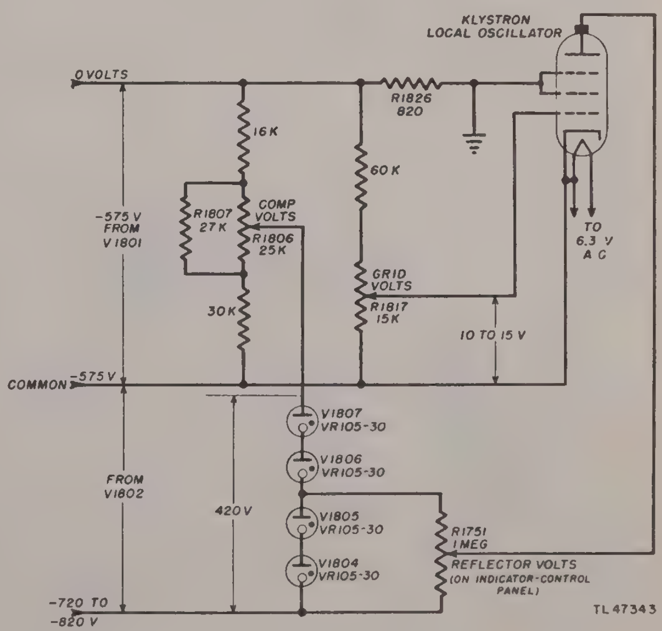

Figure 62. Local oscillator power supply, simplified schematic diagram.

is thus the regulated voltage drop tapped off by R1751 and the unregulated voltage drop selected by R1806. Potentiometer R1806, the COMP VOLTS control, is a screwdriver adjustment located on top of the chassis.

b. The complex method used for obtaining the control voltages improves the stability of the klystron. The frequency of oscillation of the klystron is about 3½ times more sensitive to changes in the reflector voltage than to changes in the cathode voltage. Advantage is taken of this characteristic to keep the frequency relatively constant. Refer to figure 62. Part of the negative voltage applied to the cathode is tapped off by potentiometer R1806 and applied to the reflector plate in series with the regulated supply. If the cathode to ground voltage of the klystron changes, the required fraction of that change is fed to the reflector plate tending to keep the frequency constant.

SECTION III
CRYSTAL MIXER

66. INTRODUCTION.

a. The function of the crystal mixer is to combine the received echo signals with the output of the local oscillator to produce an intermediate frequency which can be amplified by the i-f stages in the receiver. The frequency of the klystron is 30 megacycles above or below the frequency of the transmitter. These two frequencies are combined in the crystal mixer to produce a beat (i-f) frequency of 30 megacycles.

b. Crystals are very sensitive and easily burned out or damaged; so the following precautions must be observed.

(*1*) When not in use, keep crystals in a metal box wrapped in metal foil.

(*2*) Always ground your hand before picking up a crystal. Keep the crystal shorted with the fingers.

(*3*) Hold the hand against the mixer before inserting the crystal. This prevents static electricity from discharging through the crystal.

(*4*) Never allow the crystal current to go above 0.5 milliampere. Reduce the local oscillator coupling when inserting a new crystal or klystron.

67. CONSTRUCTION.

a. Figures 63 and 64 show the major features of construction of the partly disassembled crystal mixer. Figure 65 is a cross-section drawing of the mixer with the crystal cartridge in place, and shows inner construction details. A short metal stub at one end of the crystal is tightly gripped by springs which make contact with the quarter-wave line inner conductor. The shorted end of the line is the coupling loop in the T-R box, where the voltage induced is low. The voltage is much higher at the other end (output end of the mixer), which is open except for the crystal loading. The metal base of the cartridge makes contact with the inner conductor of the output line which carries the i-f signal to the preamplifier. The r-f components are bypassed to ground.

b. The input coupling loop of the mixer projects into the T-R box cavity at a point where the r-f signal is the greatest. This signal is fed into the mixer cavity formed by the hollow shell of the mixer, with the coupling loop at the input end and the crystal at the output end. The cavity is resonant at the frequency of the received echo signal. The input coupling loop

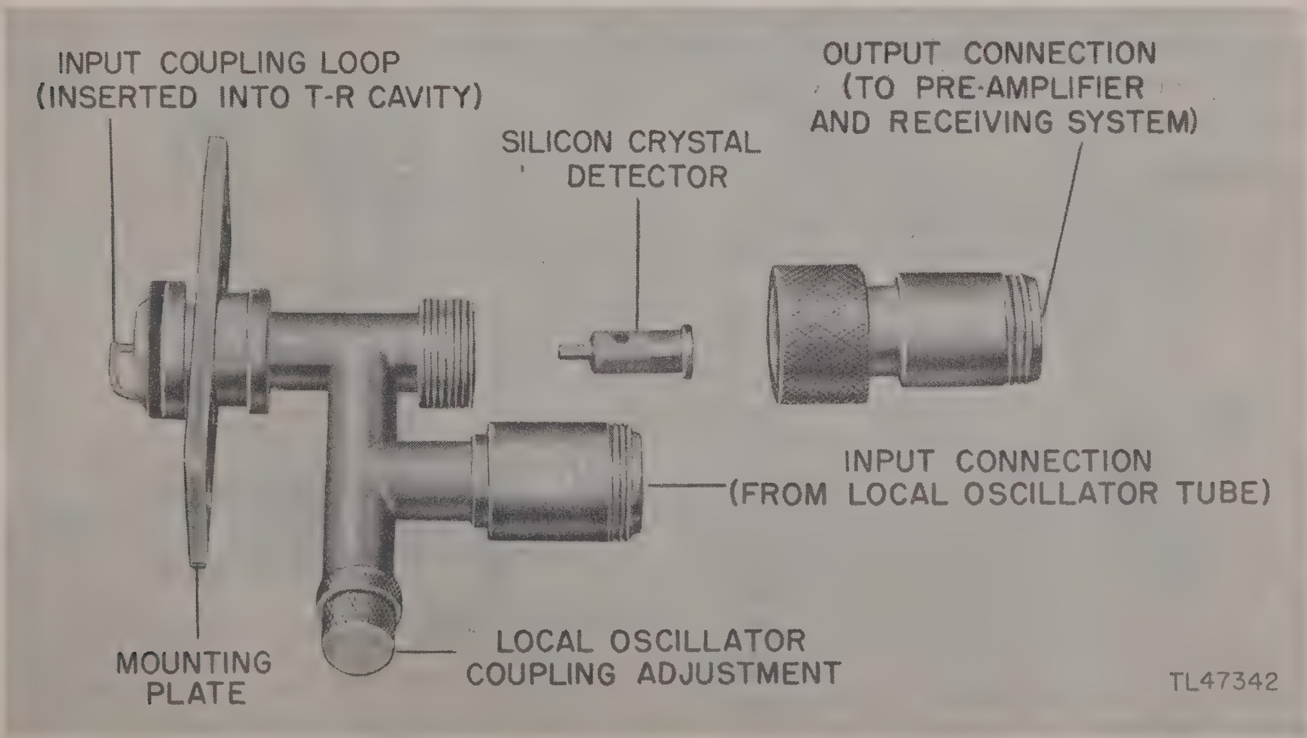

Figure 63. Construction of crystal mixer.

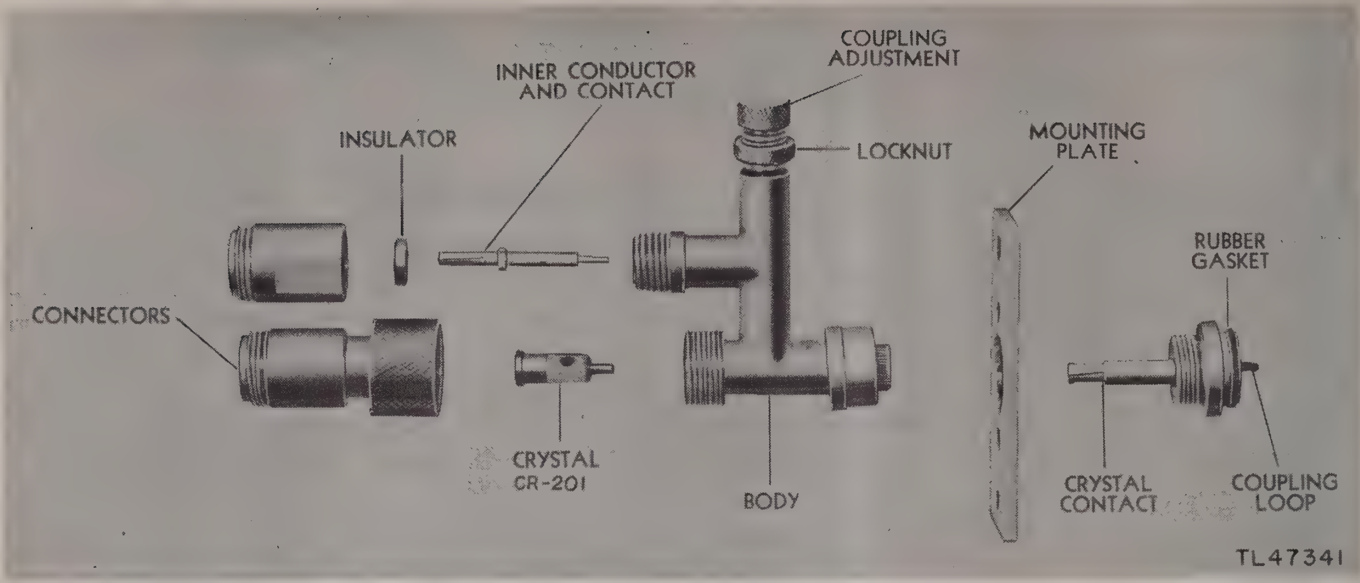

Figure 64. Crystal mixer, completely disassembled.

has a low impedance, while the output end of the cavity is open except for the crystal load and presents a relatively high impedance. The cavity acts as a step-up transformer and applies a high r-f voltage to the crystal. The voltage from the klystron is capacitively coupled into the mixer cavity by the sliding tee connection to the input line. The base contact on the crystal connects to an insulated cylindrical metal cup in the output portion of the line, and offers a low shunt impedance to the high frequency. Most of the high frequency is thus bypassed, but the r-f shunt arrangement has such a high impedance to the 30-mc signal that most of the i-f energy is passed on to the preamplifier.

68. OPERATION.

Since the input echo signal is always weak, the coupling of the crystal mixer to the T-R cavity is maintained as tight as possible. This assures that the least amount of signal is lost in the coupling. The output of the local oscillator is much stronger than the echo signal; so the local oscillator is only loosely coupled to the mixer. To prevent overload and damage to the crystal when making adjustments, the disk coupling the output of the local oscillator to the mixer cavity must be kept well out of the cavity initially, then screwed in carefully until the best signal-to-noise ratio is obtained on the scopes. The tighter the oscillator coupling to the mixer, the more noise from the oscillator is fed to the receiving system. A point is reached where increasing the local oscillator coupling causes no increase in echo strength but does increase the noise output considerably. A reading of 0.15 to 0.5 milliampere on the CRYSTAL CURRENT milliammeter indicates the proper amount of coupling. The coupling disk is adjusted by loosening the locknut and turning the knurled head of the adjusting screw. This adjustment is recommended only when a new crystal or a new klystron is installed.

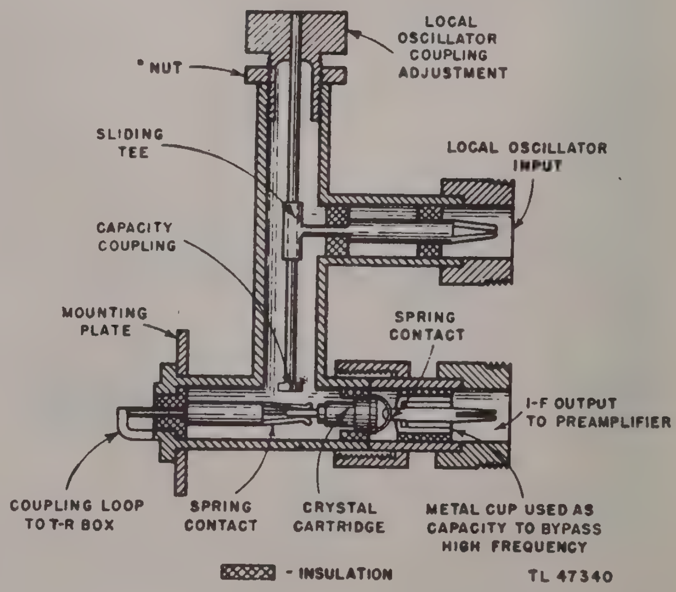

Figure 65. Crystal mixer, cross-section view.

SECTION IV
PREAMPLIFIER

69. INTRODUCTION.

The preamplifier is located in the local oscillator chassis (fig. 59) and consists of the first two stages of i-f amplification. This preamplifier circuit is specially designed to amplify with a minimum of distortion and to reduce noise pick-up which would occur if the weak i-f signal from the crystal mixer were fed directly to the receiver through a long cable. A complete schematic diagram of the preamplifier is shown in figure 80.

70. FIRST I-F AMPLIFIER (fig. 66).

The 30-mc i-f signal from the crystal mixer is fed through 6 inches of coaxial cable to the primary of the input transformer T1852. This primary is pre-tuned at the factory to resonate with the capacitances of the mixer and the cable at the 30-mc intermediate frequency. The length of the input cable is critical and any change in its length detunes the circuit, causing decreased signal strength and increased noise. The i-f signal is superimposed on the d-c component of the crystal current. After passing through the primary of the input transformer, the i-f signal is bypassed to ground by means of the filter circuit consisting of resistors R1851, R1852, and R1860 and capacitors C1853, C1852, and C1864. The d-c component of the crystal current is measured by meter M701. The secondary of transformer T1852 is tuned by means of a copper slug to resonate with the input grid capacitance of tube V1851. The amplified signal is developed across the plate load resistor R1854 and is coupled to the grid of the second i-f stage through capacitor C1857. A low value plate load resistor is used to increase the amplification bandwidth but it sacrifices the over-all gain of

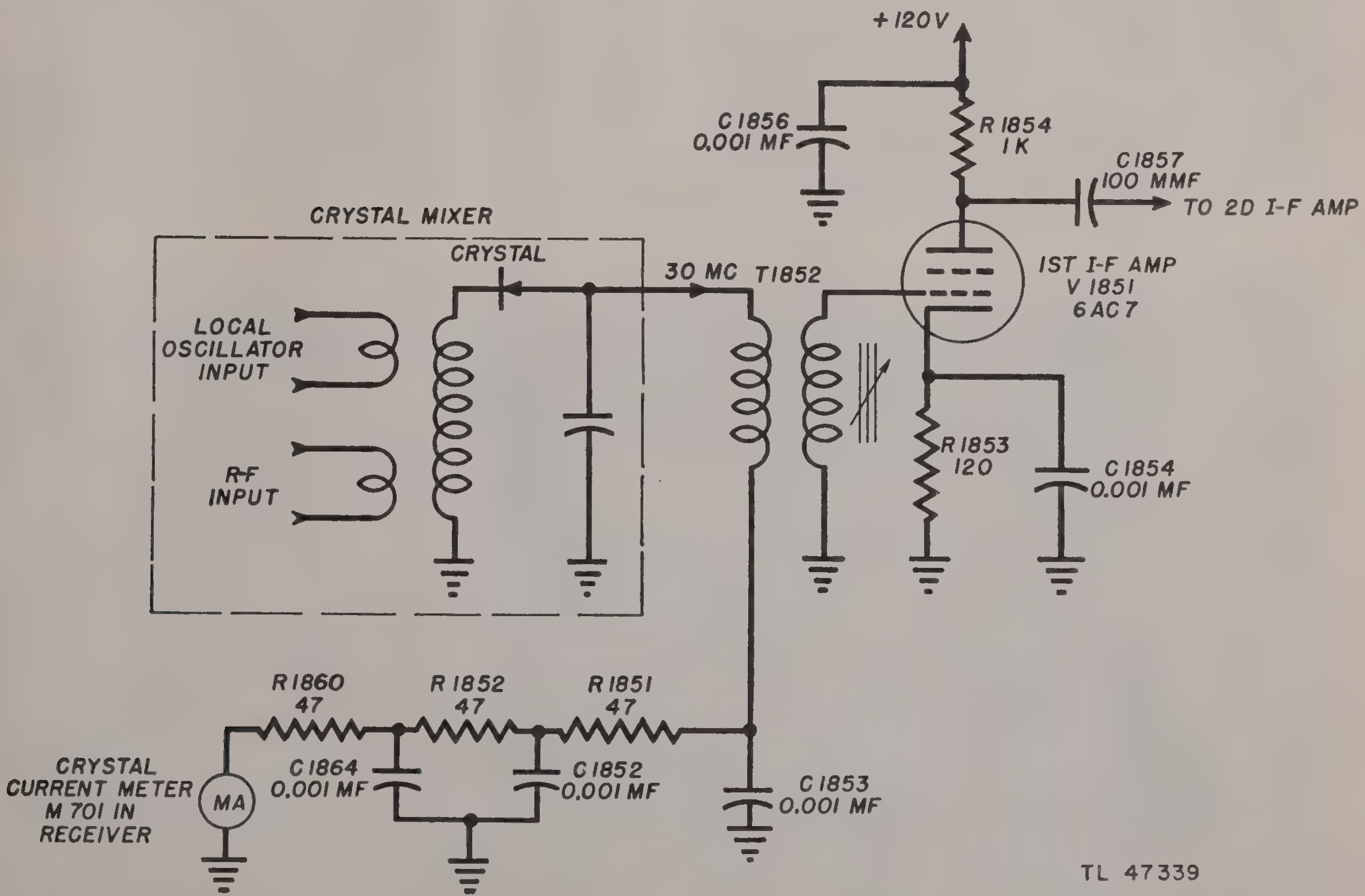

Figure 66. Preamplifier, input circuit.

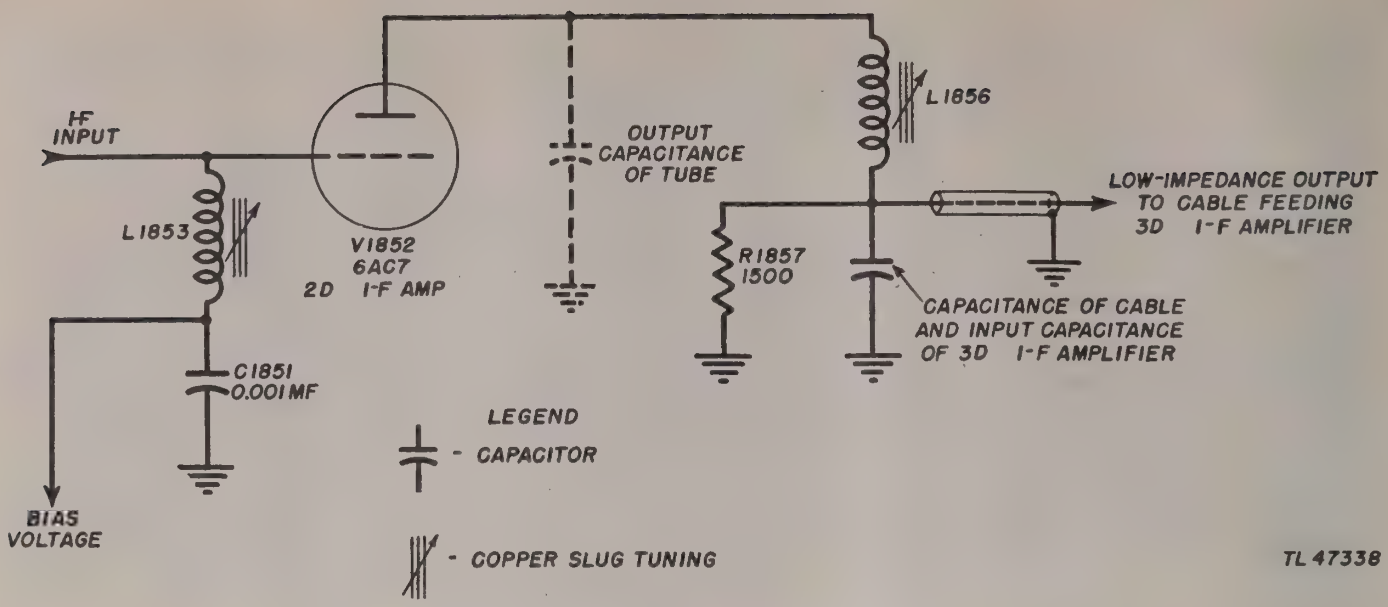

Figure 67. Preamplifier, output circuit.

the stage. This sacrifice is made up by additional i-f stages. Resistor R1853 and capacitor C1854 make up the cathode self biasing circuit to give the correct bias to the tube.

71. SECOND I-F AMPLIFIER (fig. 67).

The input circuit of the second i-f stage operates in the same manner as the input circuit of the first i-f stage. A d-c bias voltage on the grid controls the gain of this stage. The output of the second i-f stage consists of the tuned coil L1856 in series with resistor R1857. This resistor is effectively bypassed by the capacitance of the output cable and the input capacitance of the third i-f stage. Effectively the load of the tube is the high impedance parallel circuit consisting of coil L1856 and the output capacitance of the tube. The cable is tapped across the low impedance capacitance so that the gain of the stage is preserved by the tube working into the high impedance circuit and the cable matched to low impedance input.

SECTION V

RECEIVER BC-1056-C

72. INTRODUCTION.

a. The receiver (fig. 68) further amplifies the i-f signals from the preamplifier to a sufficient magnitude for operation of the various channels and circuits. The receiver chassis is located in the top center of the main rack (fig. 6).

b. There are five separate channels or circuits contained in the receiver chassis (fig. 69).

(*1*) The servo channel controlling the automatic tracking unit.

(*2*) The narrow-gate circuit controlling the servo channel.

(*3*) The range channel feeding the remote video amplifier which applies the video signals to the range scopes, PPI scope, and ART unit.

(*4*) The automatic gain control circuit controlling the gain of the receiver.

(*5*) The voltage regulator circuit providing a constant voltage output.

73. SERVO CHANNEL.

a. 3d, 4th, and 5th I-f Stages (fig. 81). The 3d, 4th, and 5th i-f stages are common to both the servo and range channels. The output is split after the 5th i-f stage and applied to the 6th i-f stage of each channel.

(*1*) The output from the preamplifier is fed through the coaxial line to jack J705 located on the back of the receiver chassis. The 75-ohm resistor R701 matches the impedance of the cable providing a maximum transfer of energy and preventing the signal from being reflected at the input jack.

(*2*) The 3d, 4th, and 5th i-f stages are similar to the 1st and 2d i-f stages in the preamplifier. They amplify the signal to the proper level for operation of the control circuits. Each of these i-f stages is coupled to the following stage by a parallel tuned circuit. The grid coils L701, L702, and L703 do not have an associated tuning capacitor, but they resonate with their own distributed capacitance, the distributed capacitance of the wiring, and the interelectrode capacitances of the tubes.

(*3*) The inductance of each grid coil is varied by means of a copper tuning slug which forms a movable core inside the coil. Electrically this slug is a shorted turn, with variable coupling. Movement of this slug enables the coil to be tuned to resonate with the tube and wiring capacitance which are effectively in shunt with

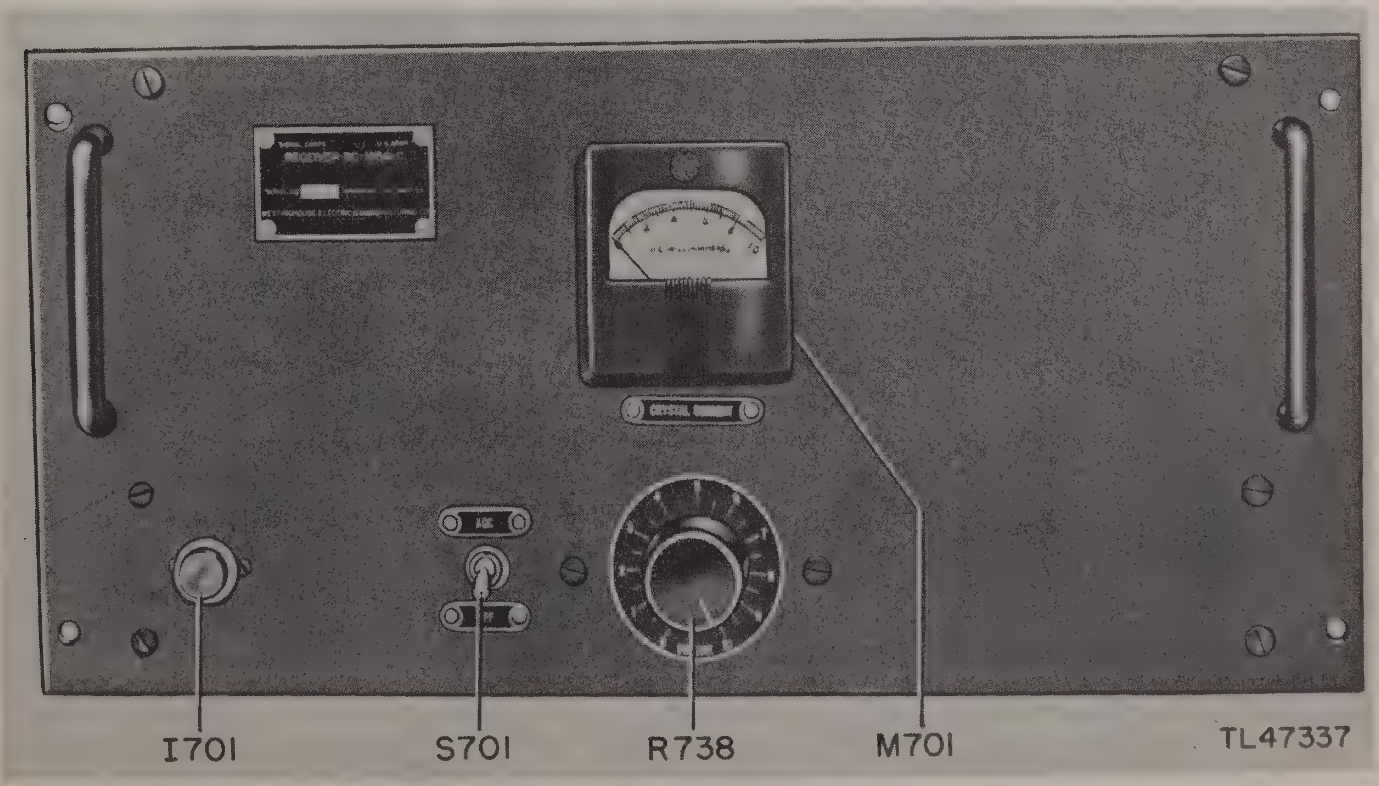

Figure 68. Receiver, front view.

the coil. As a result of this use of tube capacitance to tune the circuit, replacement of a tube in the i-f channel will sometimes affect the alignment of this stage. Tubes should not be changed in any of the stages unless defective. When a tube is removed, for checking or some other reason besides replacement, it should be replaced in the socket from which it was removed.

(*4*) The bias on the 3d i-f stage is controlled in the same manner as the bias on the 2d i-f stage in the preamplifier. These two stages control the gain of the receiving system.

b. 6th and 7th I-f Stages (fig. 70).

(*1*) The 6th i-f stage V704 is normally cut off because the screen grid is tied to the negative 105-volt supply through the voltage-divider network R757 and R758. While this 6th i-f stage is cut off, all the following stages and the automatic tracking unit are inoperative. When the positive narrow gate or the positive input from the automatic range tracking unit is applied to the screen of V704, the tube conducts for the duration of the gate. The i-f signal which is within this gate is amplified by V704 and passed on to the 7th i-f stage of the servo channel. The position of switch S702 determines whether the narrow-gate pulse or the automatic range tracking unit N^2 gate pulse is applied to the screen of V704.

(*2*) The 7th i-f stage V705 is similar to the 4th and 5th i-f stages. It amplifies the signal and feeds it to the video detector through coupling capacitor C722.

c. Video Detector (fig. 71). The video detector consists of one half of the dual triode V706. The plate of this section is grounded to shield the amplifier section of the tube from the signal applied to the detector section. The i-f signal is applied to the cathode and the grid serves

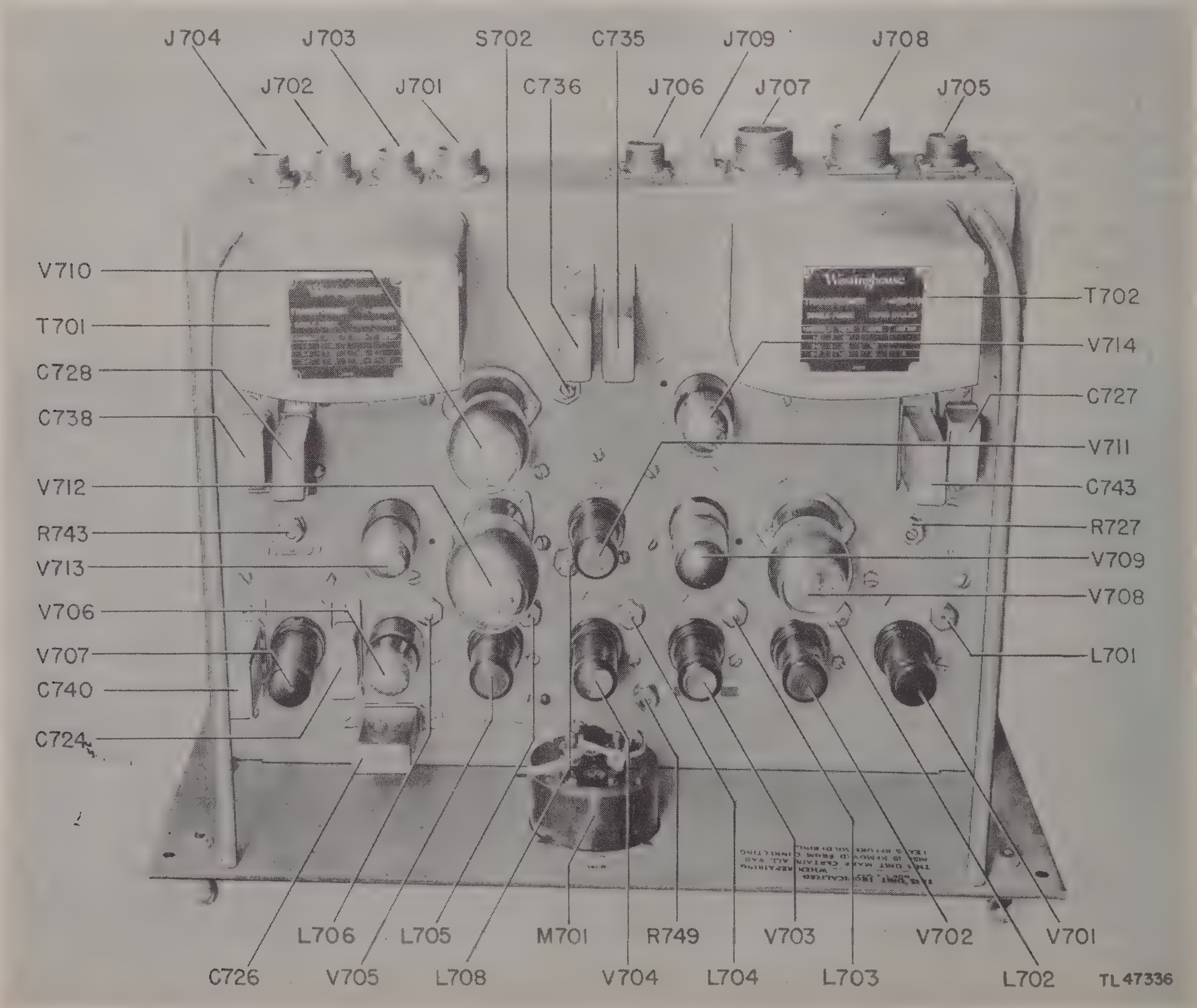

Figure 69. Receiver, top view.

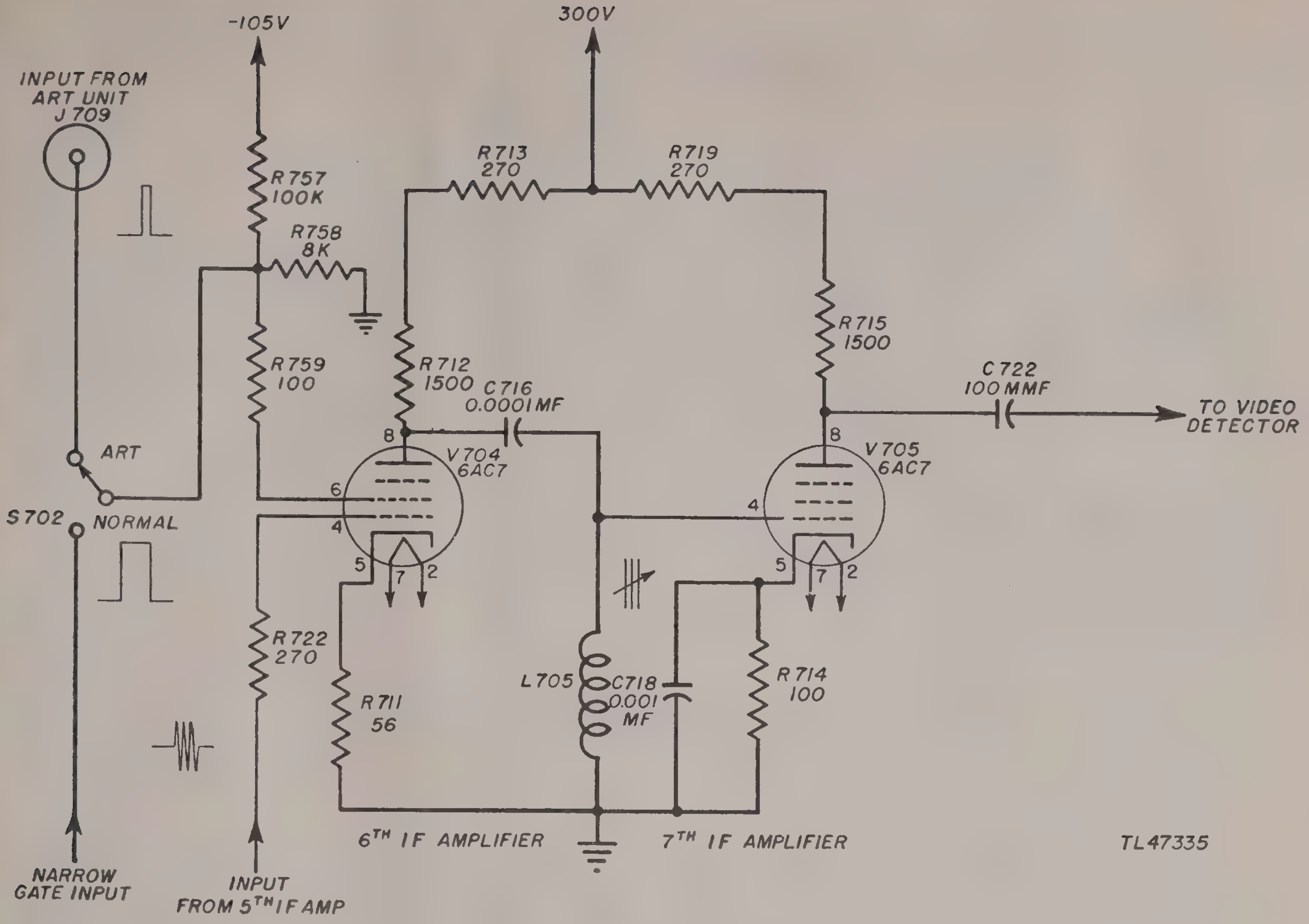

Figure 70. Sixth and seventh i-f amplifiers, simplified schematic diagram.

as the plate. On the negative swing of the signal the grid draws current developing a voltage across R746. The output is detected and developed across L707 and C723, and the video signal is applied to the grid of the 1st video amplifier.

d. Video Amplifiers.

(*1*) The 1st video amplifier consists of the other half of the dual triode V706. It is normally conducting, the grid being grounded and the bypassed cathode resistor R725 providing bias. The plate is tied to the 300-volt supply

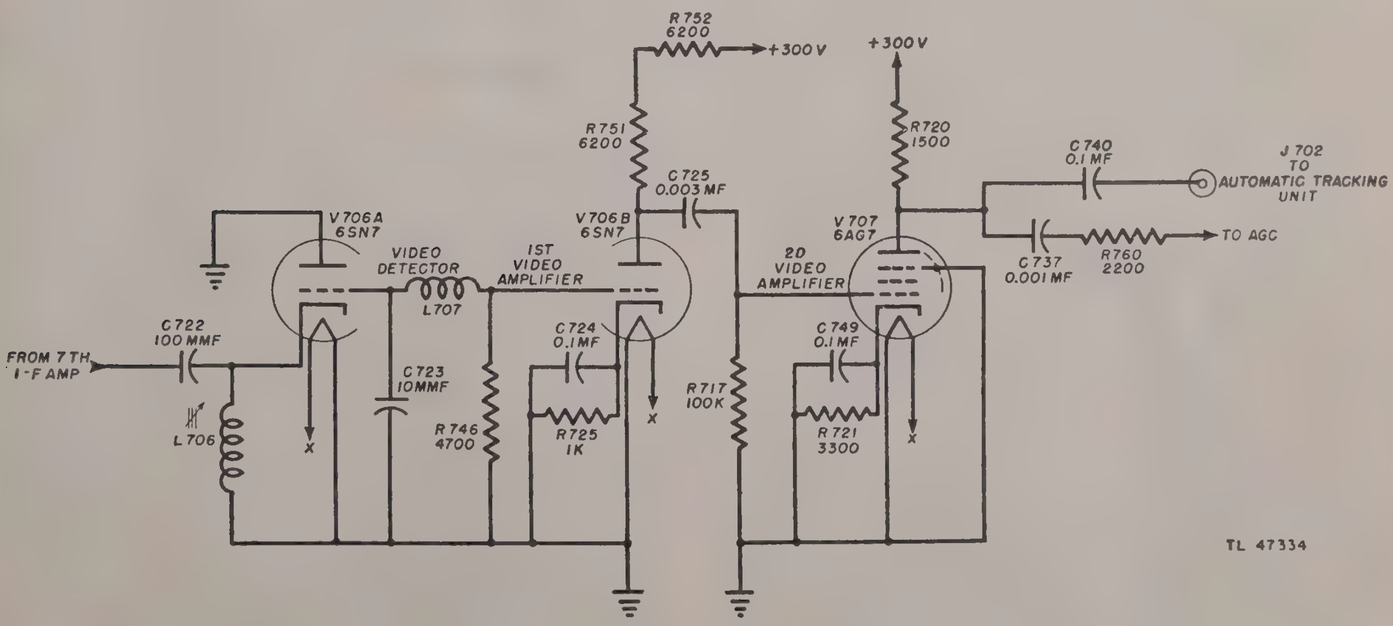

Figure 71. Servo channel video detector and amplifiers, simplified schematic diagram.

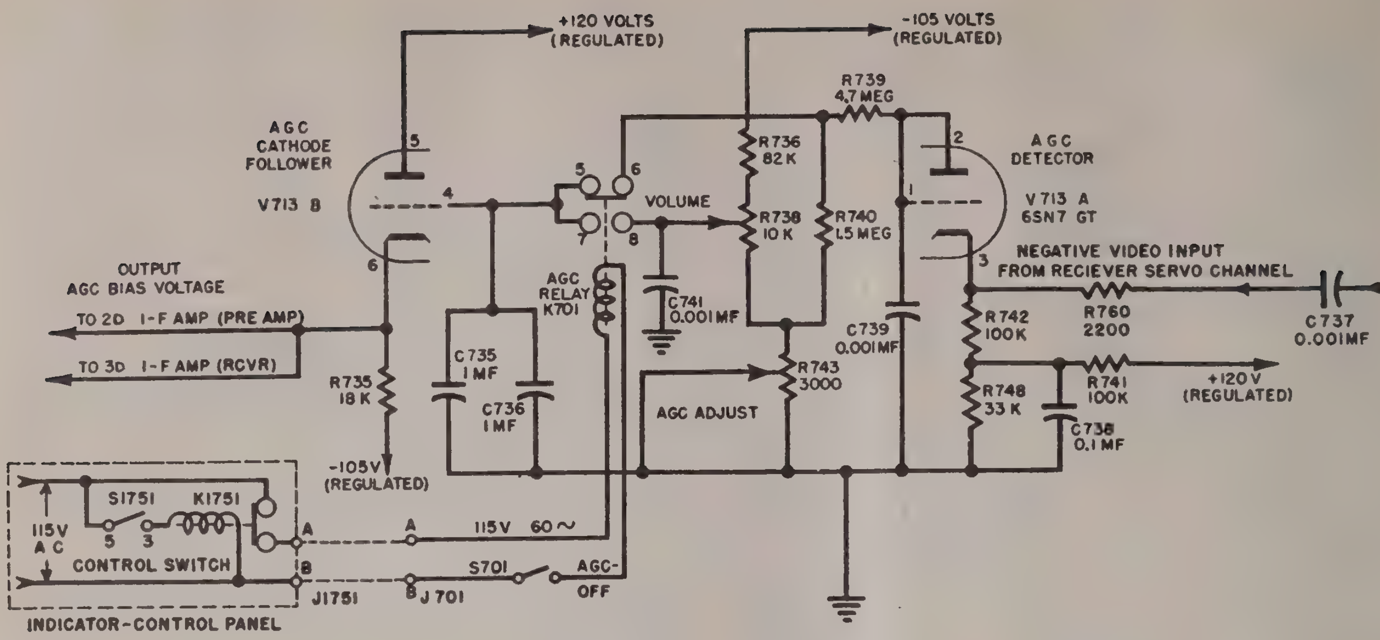

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Figure 72. AGC circuit, simplified schematic diagram.

through R751 and R752. The negative video output from the detector tends to cut this stage off, the plate voltage rises, and the positive output signal is coupled to the grid of V707 through capacitor C725.

(*2*) The 2d video amplifier V707 is a beam power tube operated as a class A amplifier. The bypassed cathode resistor R721 provides sufficient bias to keep the stage at the proper operating level. The positive input signal from the plate of V706 to the grid of V707 causes the tube to conduct more heavily. Since the operating range is linear (class A), there is a minimum of distortion in the negative video output. This output is coupled through C737 and R760 to the automatic gain control circuit, and through C740 to the output jack J702 from which it is fed to the automatic-tracking unit.

74. RANGE CHANNEL.

a. The 3d, 4th, and 5th i-f stages are common to both the servo and range channels and operation of these stages is explained in subparagraph 73 **a**.

b. The output from the 5th i-f stage is fed to the 6th i-f stage V711 in the range channel for further amplification. Refer to figure 81. This stage is a conventional i-f amplifier. Potentiometer R749 (the SENSITIVITY CONTROL) is in series with the bypassed cathode resistor R729 and provides a varying amount of bias, thus controlling the output of the stage. When a signal is in the narrow gate, the AGC circuit reduces the gain of the common i-f stages, thus reducing the over-all gain of the range channel. The SENSITIVITY CONTROL is adjusted to compensate for this over-all reduction and to give the range channel output the proper amplitude. The 6th i-f stage output circuit is similar to that of the 2d i-f stage except that capacitor C729 has been added to increase the band width. The output is coupled by capacitor C732 to output jack J706 and the remote video amplifier for further amplification.

75. AUTOMATIC GAIN CONTROL CIRCUIT (fig. 72).

a. Function of the Circuit. The automatic gain control circuit consists of the dual triode tube V713 using one half as a diode detector and the other half as a cathode follower. The output bias voltage of the circuit controls the bias on the grids of the 2d and 3d i-f stages.

(*1*) The input to the AGC circuit is the negative video output of the servo channel, and is coupled to detector V713A through capacitor C737. The grid and plate of detector V713A are tied together, and the tube is cut off in the absence of an input signal. The cathode potential is about plus 30 volts due to the voltage-divider network R748 and R741 between plus 120 volts and ground.

(2) When a strong signal is within the narrow gate, the negative video signal applied to the cathode of V713A causes this section to conduct producing a negative output which is coupled to grid 4 of the cathode follower. This voltage tends to cut off the normally conducting cathode follower, causing the cathode potential to drop towards the negative 105-volt bias level which is applied through the resistor network R735, R736, R738, and R743. Since this AGC voltage is applied as a negative bias to the 2d and 3d i-f stages, it will lower the gain of the receiver and tend to keep the video output of the servo channel from rising above the normal level.

(3) When a weak signal is within the narrow gate, the negative video signal applied to the cathode of V713A will not overcome the cathode bias and the tube will not conduct. The voltage applied to the grid of the cathode follower will then be the voltage at the junction of R743 and R738. This voltage is determined by the setting of the AGC ADJUST control R743 which is normally set so that the voltage at the cathode follower V713B will be zero. Under these conditions, the AGC bias on the 2d and 3d i-f stages will be zero and the receiver will operate at maximum gain.

(4) The filter network in the AGC circuit smooths out the rectified voltage fed to the grid of the cathode follower V713B so that fluctuations in the AGC voltage will not be fed back to the i-f channel to cause distortion of the receiver output. The time constant of the AGC circuit filters is also long enough to smooth out the peaks of the 30-cycle error signal, but is not short enough to completely smooth out this 30-cycle error signal.

(5) Sudden strong signals will overload the receiver momentarily, but the AGC circuit prevents jamming the receiver by the action of resistor R739 which makes it difficult to charge capacitors C735 and C736 suddenly.

b. Automatic and Manual Control. Either automatic or manual operation of the circuit may be used, depending on the setting of the AGC-OFF switch S701 and the CONTROL SWITCH on the indicator-control panel. When relay K701 is de-energized (switch S701 in the AGC position), the circuit operates automatically. When relay K701 is energized (switch S701 in tne OFF position), the circuit may be controlled manually by use of the VOLUME control located on the receiver front panel. When the CONTROL SWITCH is in the AUTOMATIC position relay K701 is de-energized regardless of the setting of switch S701. When S701 is in the AGC (open) position relay K701 is de-energized regardless of the position of the CONTROL SWITCH. This arrangement is provided so that AGC will be used when the equipment is in automatic tracking.

c. AGC ADJUST Potentiometer. The AGC ADJUST potentiometer R743 is provided to set the cathode of V713B at ground potential when the VOLUME potentiometer R738 is in the maximum gain position. This setting is necessary because the 2d and 3d i-f stages require zero grid bias for maximum gain. For adjustment, remove the 3d i-f V701 from its socket, turn the CONTROL SWITCH to the MANUAL position, throw switch S701 to the OFF position, turn the VOLUME control to its maximum gain position, and set the AGC ADJUST potentiometer until the voltage measured at pin 4 of socket X701 is zero volts.

76. NARROW-GATE CIRCUIT.

A simplified schematic diagram of the narrow-gate circuit is shown in figure 73.

a. The narrow gate amplifier V710 is the first stage of the circuit. The negative narrow gate from the range unit is fed to the grid of V710 through jack J703. In the absence of the gate V710 operates at saturation, but is cut off when the negative narrow gate is applied. The output of V710, a positive voltage, is fed to the grids of V712 and V714 through capacitor C734.

b. The dual triode V714 is used as a diode voltage limiter for setting the peak positive-voltage level of the output of V712. When the peak value of the gate from V710 exceeds the 120 volt bias on the cathode of V714 then V714 conducts. Refer to figure 74. When V714 conducts, it effectively shunts grid resistor R733 and prevents the voltage on the plates of V714 from rising above 120 volts.

c. The cathode follower V712 is a beam power 6L6 connected as a triode and is normally conducting. It is self biased, but the screen of the 6th i-f and the grid of the 2,000-yard range scope cathode-ray tube are isolated from the bias potential on the cathode of V712 by

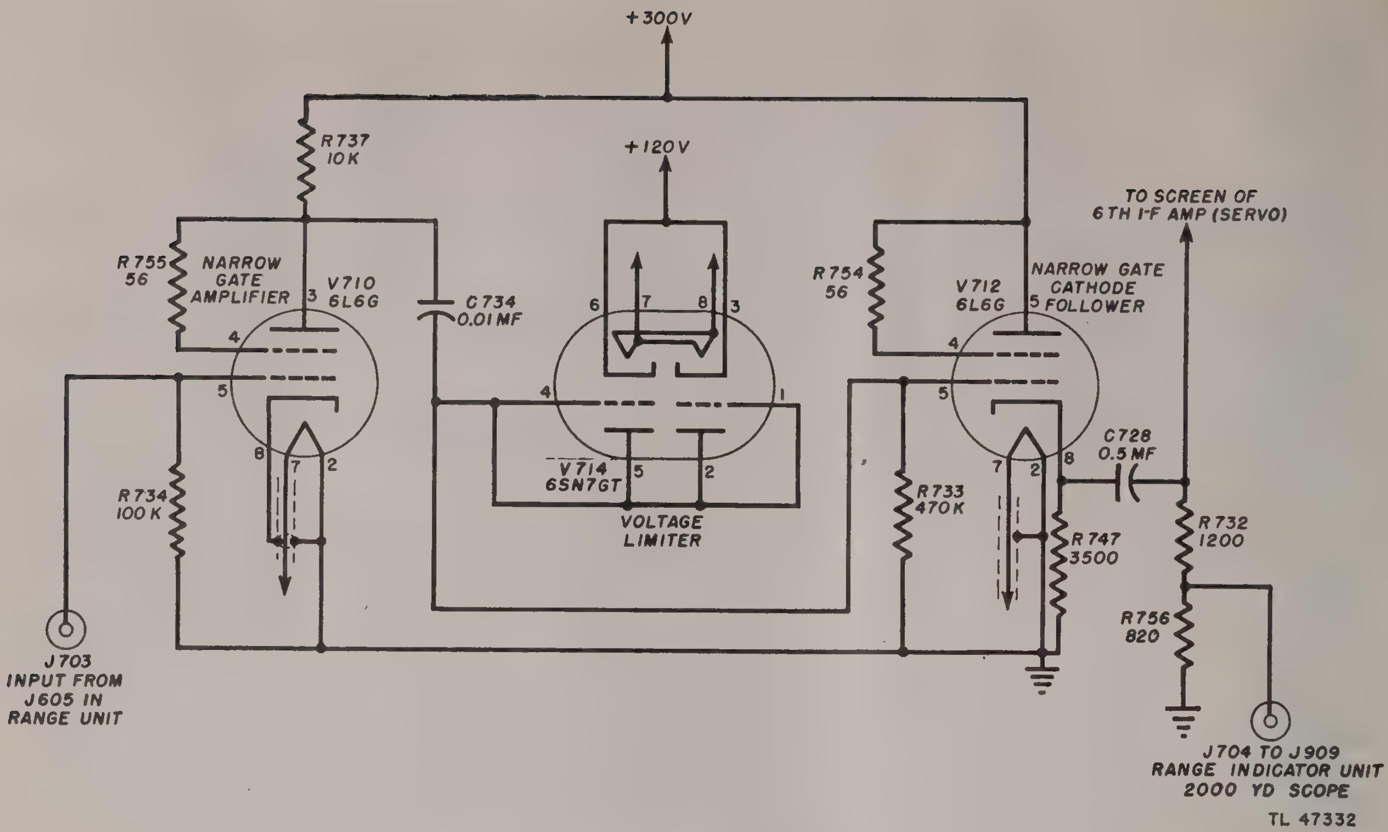

Figure 73. Narrow-gate circuit, simplified schematic diagram.

capacitor C728. The positive narrow gate applied to the grid of V712 causes the tube to conduct heavily and a positive rectangular voltage pulse is developed across the cathode resistor R747. If switch S702 is in NORMAL, (fig. 70)

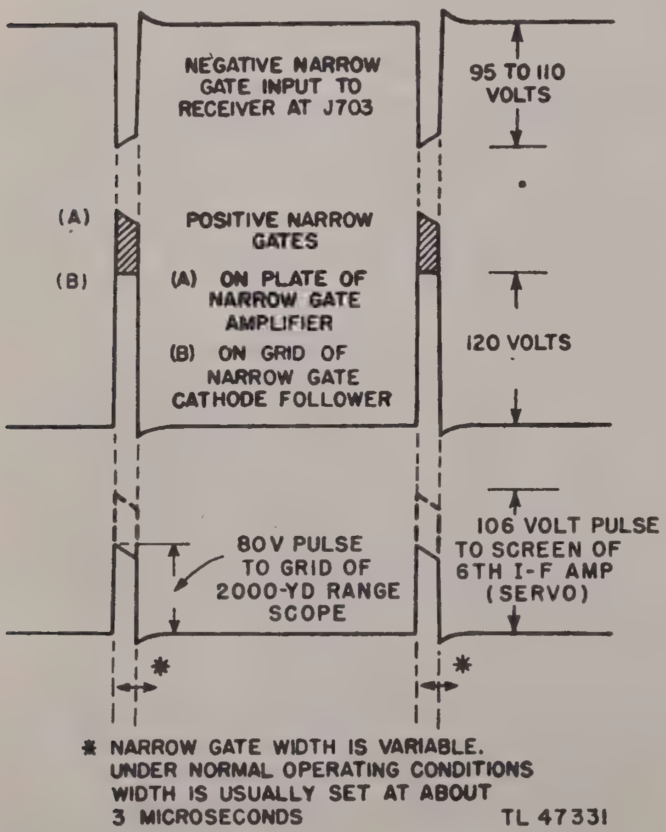

Figure 74. Operation of narrow-gate circuit.

this output is applied to the 6th i-f screen, neutralizing the negative bias on this screen, and causing the servo channel to respond to the selected received signal. A second output is taken from the junction of R732 and R756 and fed through jack J704 to the 2,000-yard range scope.

77. VOLTAGE REGULATOR CIRCUIT.

A simplified schematic diagram of the voltage regulator circuit is shown in figure 75. This circuit consists of the voltage regulator V708 and the voltage regulator control V709. The circuit is used to provide a regulated 120-volt d-c supply. Tube V709 is used to control tube V708. Tube V708 acts as an automatically-controlled variable resistor in series with the regulated 120-volt output. The variations of grid voltages at the grid of V709 are fed to the control grid of V708 in such a way as to keep the output voltage at the cathode of V708 constant. Resistors R726, R727, R728, and R718 are connected as a voltage divider between the 300-volt plate supply and the fixed negative 105-volt supply. The voltage at the cathode of V708 is set at 120 volts by the VOLT REG ADJ potentiometer R727. When R727 varies the bias on V709 it varies the voltage at the plate of V709 and at the grid of V708. An increase in

the unregulated 300-volt supply raises the potential at the control grid of V709 which causes V709 to conduct more heavily. This causes a drop in the plate voltage of V709 and a less positive potential appears on the control grid of V708. This increases the resistance of V708 and lowers the potential at the cathode so as to maintain the constant 120-volt output. Any tendency of a decrease in the unregulated 300-volt supply is controlled in the same manner. The 0.1 mf capacitor C727 puts a greater percentage of any rapid voltage variation on the grid of V709 and results in better regulation against output changes caused by rapid variations in the load current or line voltage.

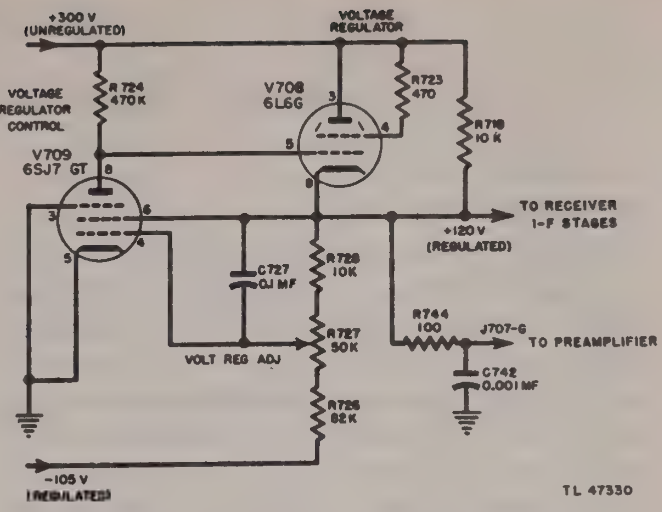

Figure 75. Voltage regulator circuit, simplified schematic diagram.

SECTION VI
REMOTE VIDEO AMPLIFIER

78. INTRODUCTION.

The remote video amplifier contains the rest of the stages of the range channel of the receiver system. Because of lack of space on the receiver chassis, the seventh i-f stage, video detector, and the three video amplifiers are located on the rear of the field power supply chassis (fig. 76). An extra video stage in the range channel is necessary because of the losses in the cables between the remote video amplifier and the receiver, the range indicator unit, and the PPI unit. A complete schematic of the remote video amplifier is shown in figure 82.

79. SEVENTH I-F AMPLIFIER.

The 7th i-f amplifier is similar to the third i-f amplifier in the receiver. The input circuit is designed to match the impedance of the coaxial line from the receiver. No gain-control voltage is fed to the grid; so it is tied directly to ground through the input coil L1101.

80. DETECTOR AND FIRST VIDEO AMPLIFIER (fig. 77).

a. The video detector uses one half of the dual triode V1102. In order to have the proper bias on the first video amplifier all the elements

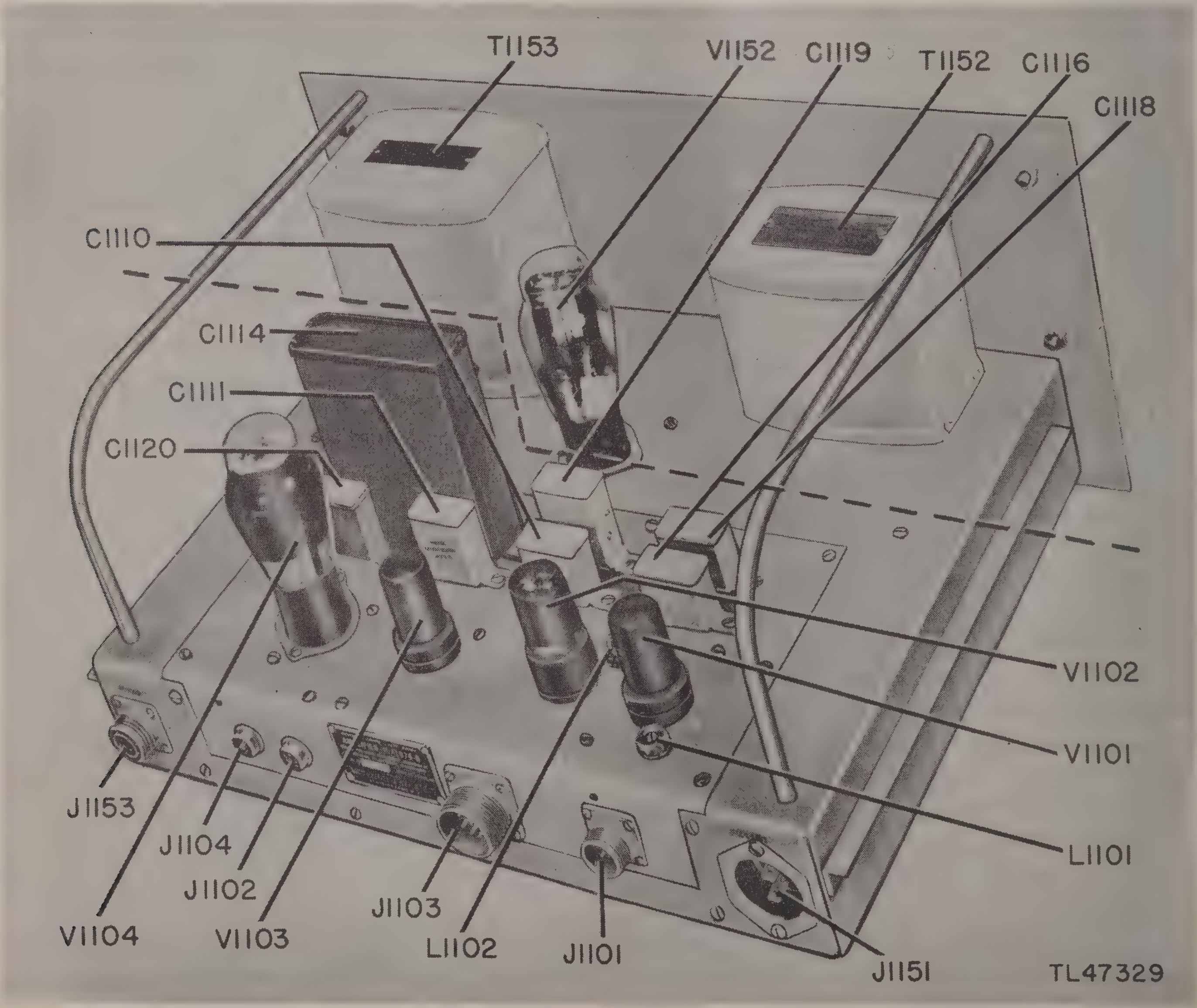

Figure 76. Remote video amplifier, top view.

on the video detector are operated at minus 5 to 7 volts by means of the voltage divider R1123 and R1125 which is connected between the −105 volts supply and ground. In other respects the detector is similar to a conventional pulse detector. The incoming i-f signals are applied to the grid and cause the detector to conduct on the positive alternations. The positive video signals produced at the cathode of V1102 are coupled to the grid of the 1st video amplifier.

b. The 1st video amplifier uses the other half of the dual triode V1102. The choke coil L1103 is directly coupled to the grid, maintaining the d-c bias and the signal and noise at the proper level. In the absence of a signal the 1st video amplifier is cut off by the negative 7-volt bias applied to the grid through voltage divider network R1123 and R1125. When the positive video signals are coupled to the grid through coil L1103, then V1102 conducts and produces a negative video signal which is applied to the grid of the 2d video amplifier V1103 through capacitor C1108.

81. SECOND AND THIRD VIDEO AMPLIFIERS.

a. In addition to serving as an amplifier, the 2d video amplifier V1103 (fig. 82) is also designed to limit the maximum amplitude of the signal applied to the range scopes and PPI scope. Tube V1103 is normally conducting but is cut off by the negative video signal applied to its grid. No matter how strong the signal applied to the grid, the signal developed at the plate of V1103 can never exceed the difference between the 300-volt plate supply and 200 volts because even with V1103 conducting the normal voltage at the plate is 200 volts. Capacitor C1108 and resistor R1107 form the grid leak coupling circuit and have the effect of keeping the noise level on the screen of the scopes fairly constant so that weak signals can be more easily detected. The stronger the positive peaks of noise voltage, the greater the negative bias produced by the R-C circuit C1108 and R1107 and consequently the more reduction in noise amplification by V1103. Because of this action the noise level on the scopes is approximately constant.

b. The 3d video amplifier (fig. 82) uses the beam power tube V1104 which is normally cut off by the grid bias supplied from the negative 105-volt supply through the voltage-divider network R1115 and R1114. The positive video signals from the plate of V1103 cause V1104 to conduct. The negative output from the plate of V1104 is coupled through C1113 to jack J1102 and the range indicator unit, and through C1115 and R1122 to jack J1104 and the PPI scope. The voltage drop across R1122 limits the amplitude of the signal fed to the PPI scope.

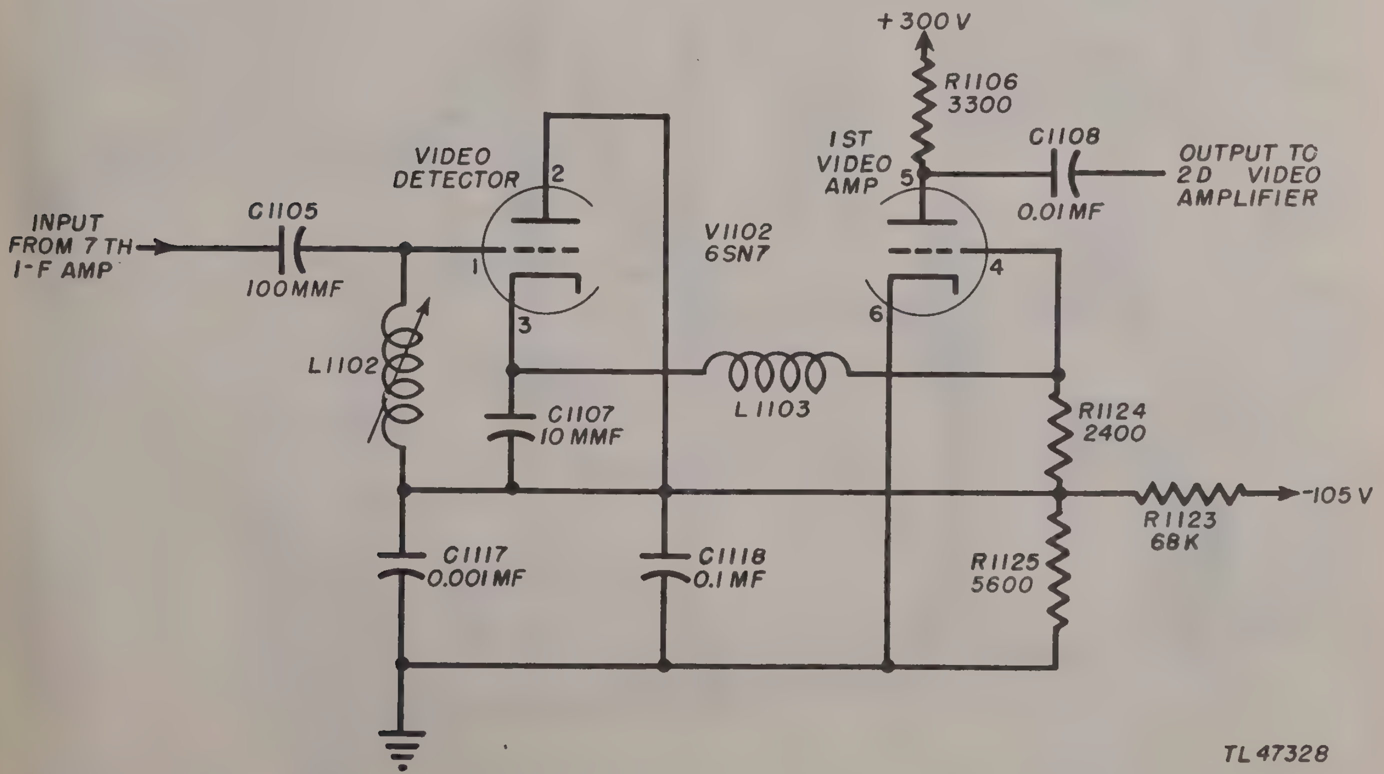

Figure 77. Video detector and amplifier, simplified schematic diagram.

SECTION VII
RECEIVER POWER SUPPLY

82. GENERAL.

A top view and a complete schematic diagram of the receiver power supply are shown in figures 78 and 83. The chassis contains two separate units, the unregulated plus 300-volt supply, and the regulated negative 105-volt supply. The 115-volt 60-cycle a-c input is applied through jack J1003. One side of the line passes through connections in the base of V1004. This connection provides an effective interlock and unless the voltage-regulator tube V1004 is in its socket and piugs P1002 and P708 are connected to the proper sockets a-c voltage will not be applied. Pilot light I1001 indicates that filament voltage is being applied to the remote video amplifier. The filament voltages for the receiver and preamplifier are supplied by separate filament transformers on each chassis. A-c input to the receiver filament transformer comes from the receiver power supply chassis through pins A and G of jacks J1002 and J708 and goes to the preamplifier filament transformer through pins A and B of jacks J107, J206, and J1851 (fig. 57).

83. HIGH-VOLTAGE SUPPLY.

a. Unregulated Supply. The unregulated plus 300-volt supply uses tubes V1001 and V1002 in a full-wave rectifier circuit. Each tube has its plates tied together so that each tube acts as a half-wave rectifier and the two tubes are then connected in a full-wave rectifier circuit. This increases the current-carrying capacity of the circuit. The filtered output is connected to jacks J1001 and J1002.

b. Regulated Supply. The regulated negative 105-volt supply uses tube V1003 in a full-wave rectifier circuit. The filtered output is applied through resistor R1002 across the voltage-regulator tube V1004. This VR-105-30 cold-cathode regulator maintains a constant drop of 105 volts across its terminals. The regulated negative output is connected to jacks J1001 and J1002.

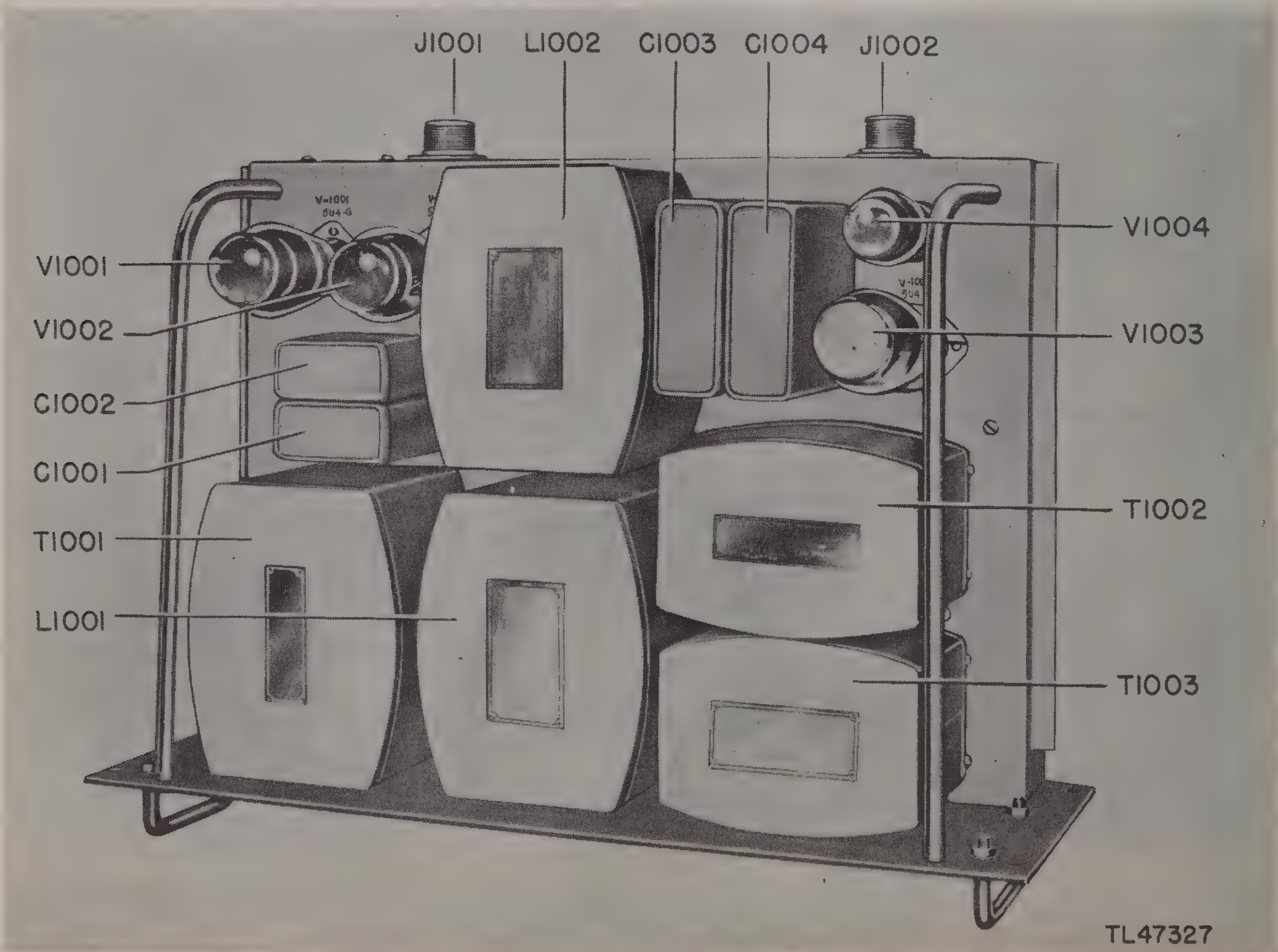

Figure 78. Receiver power supply, top view.

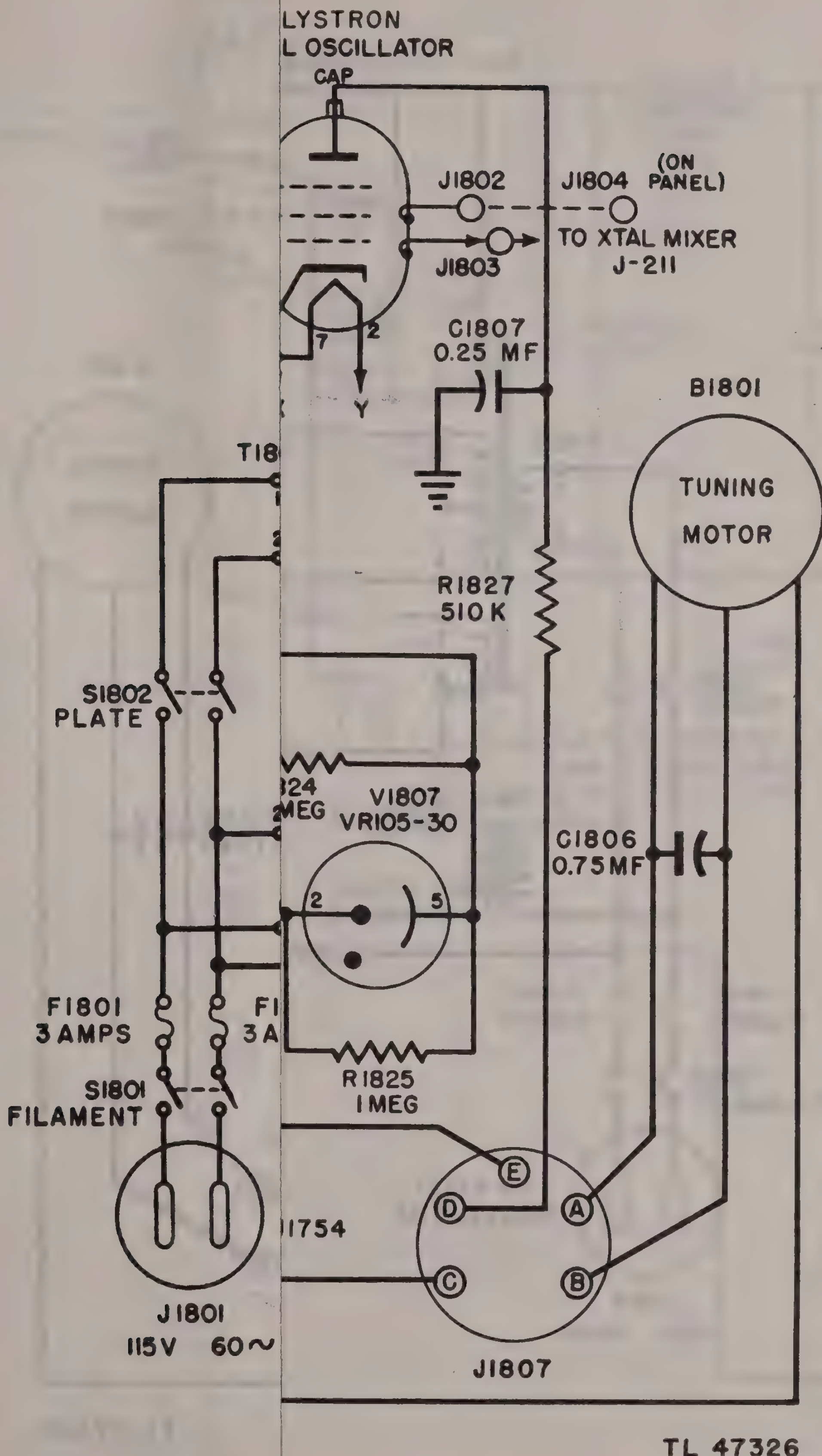

Figure 79. Local oscillator, complete schematic diagram.

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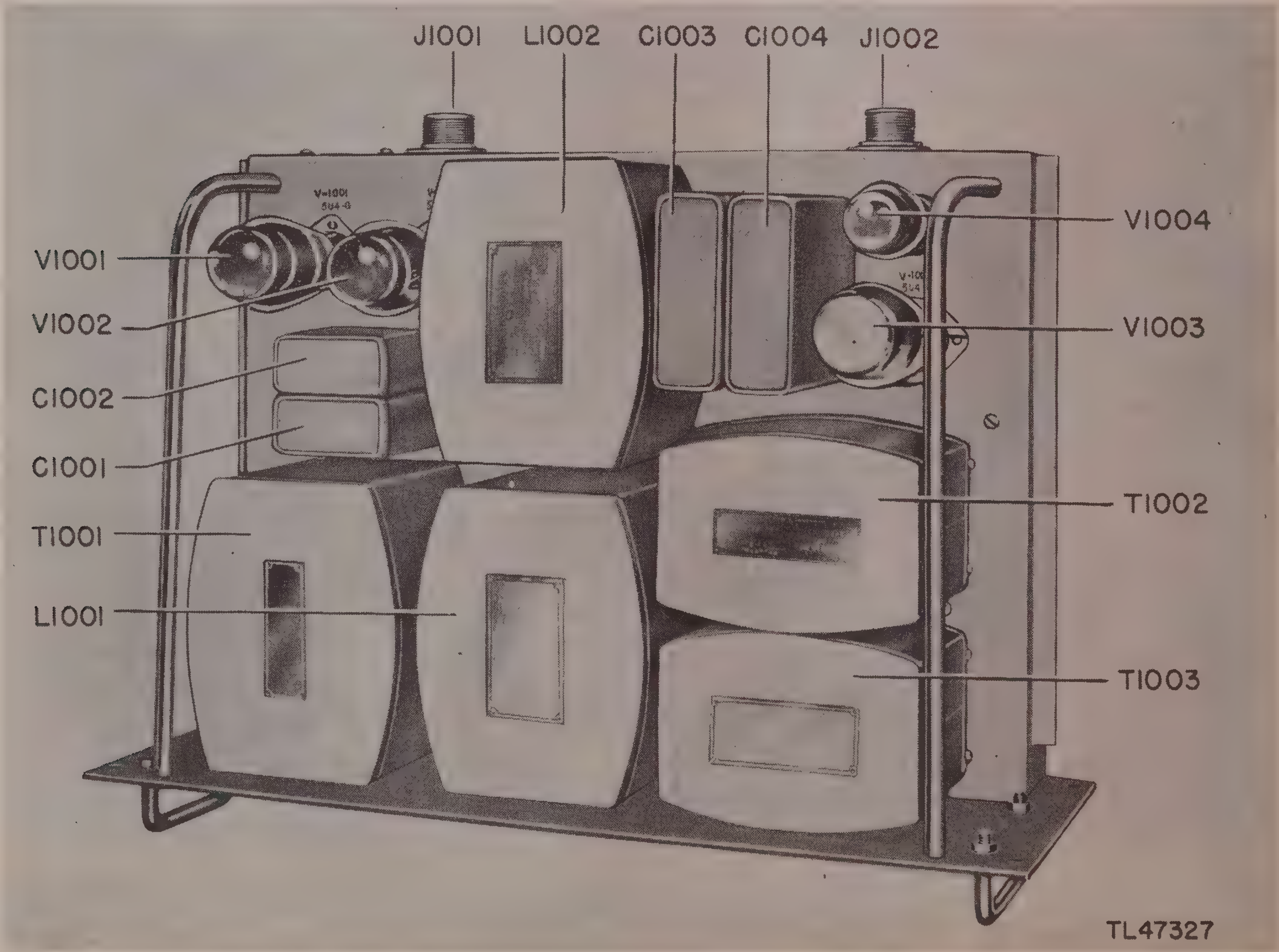

Figure 78. Receiver power supply, top view.

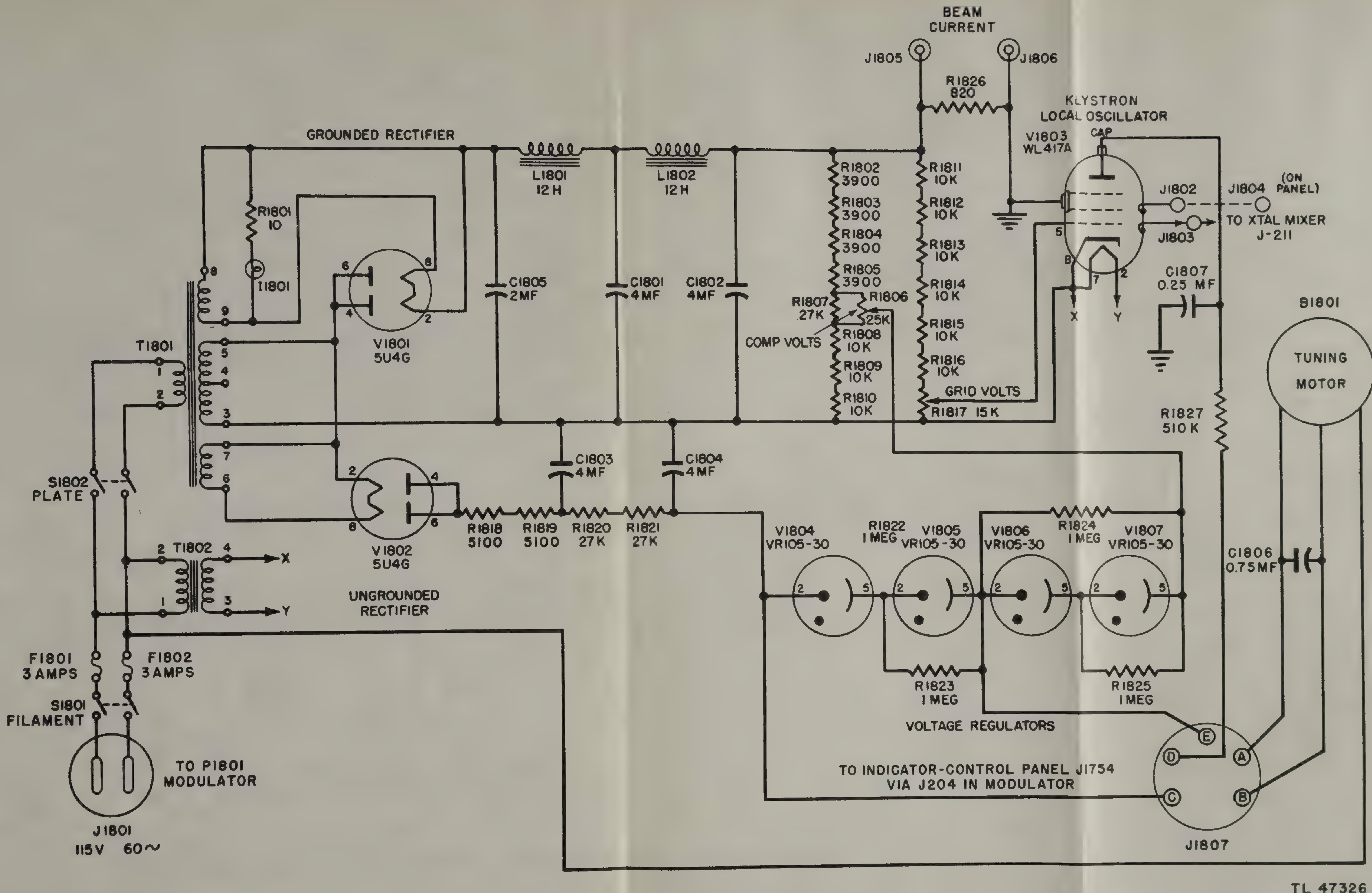

Figure 79. Local oscillator, complete schematic diagram.

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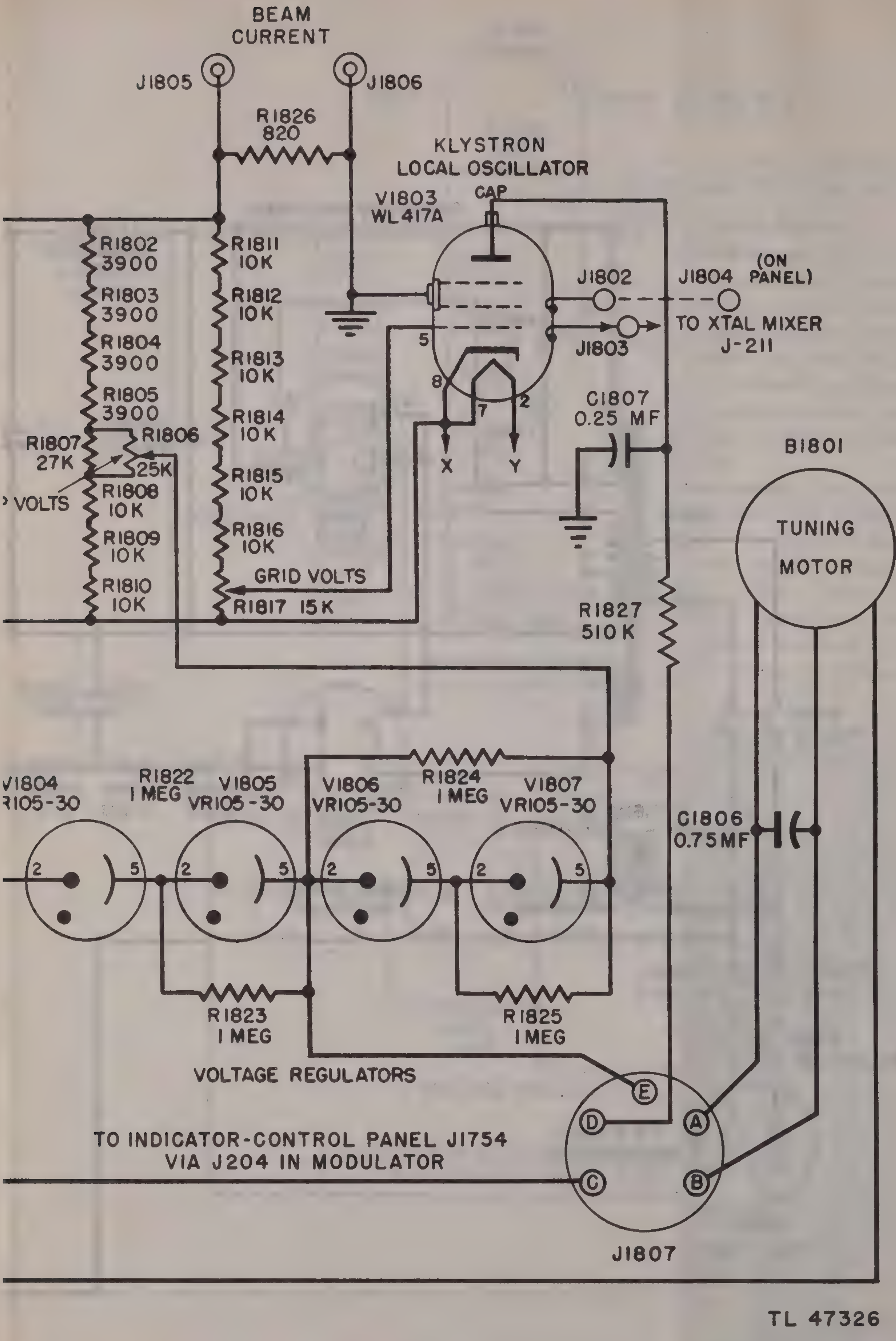

Figure 79. Local oscillator, complete schematic diagram.

Figure 80. Preamplifier, complete schematic diagram.

Figure 79. Local oscillator, complete schematic diagram.

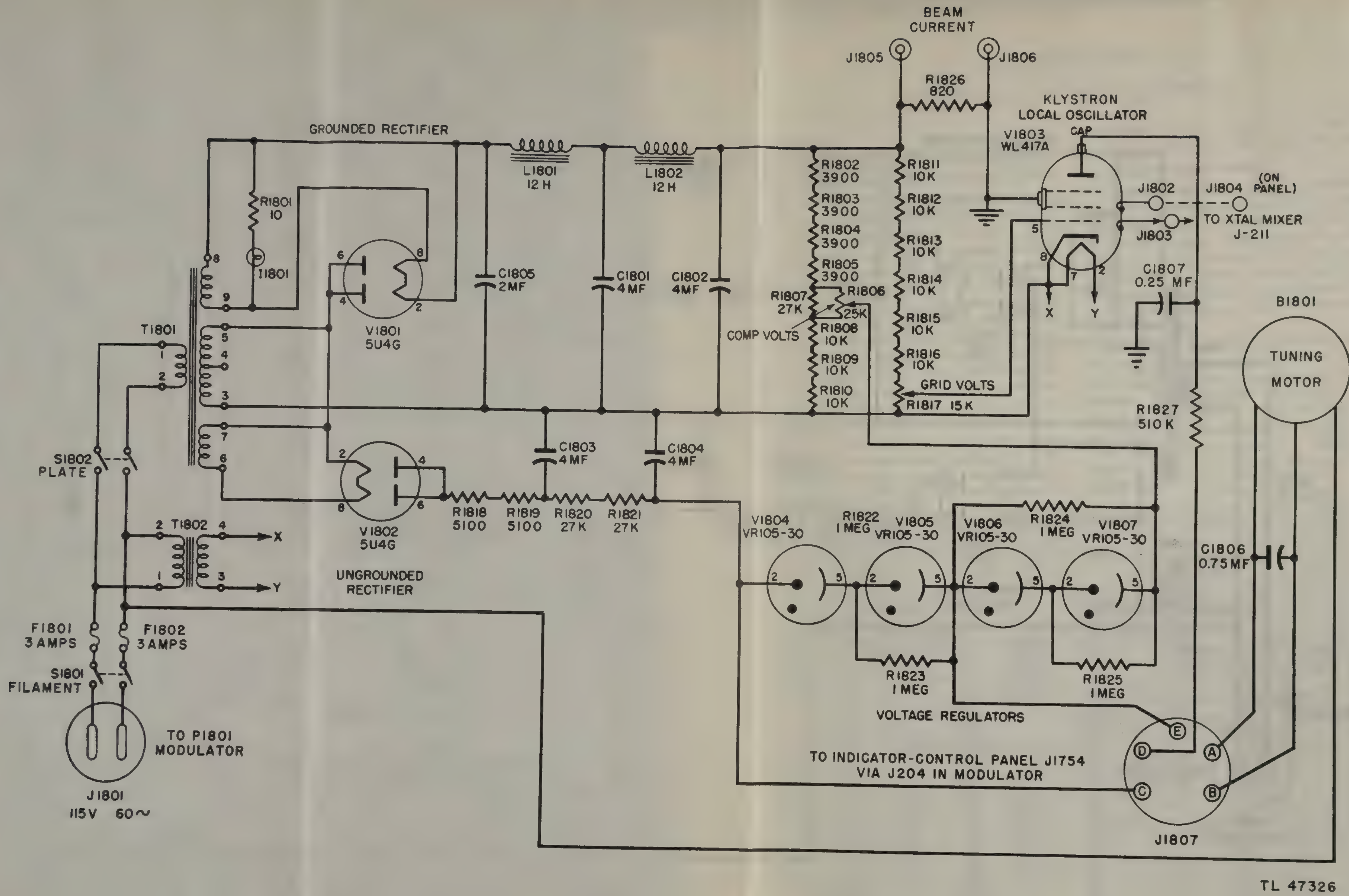

Figure 79. Local oscillator, complete schematic diagram.

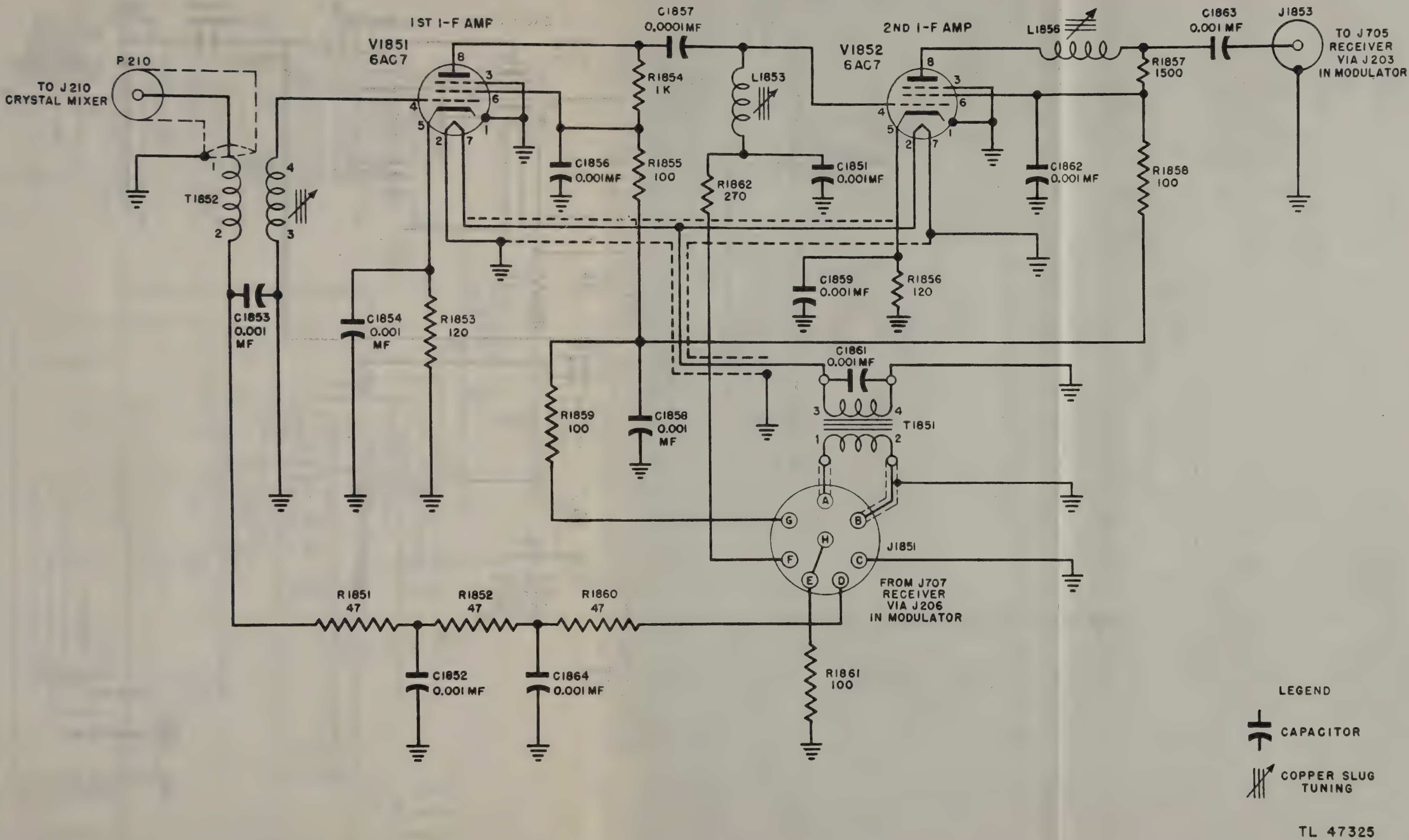

Figure 80. Preamplifier, complete schematic diagram.

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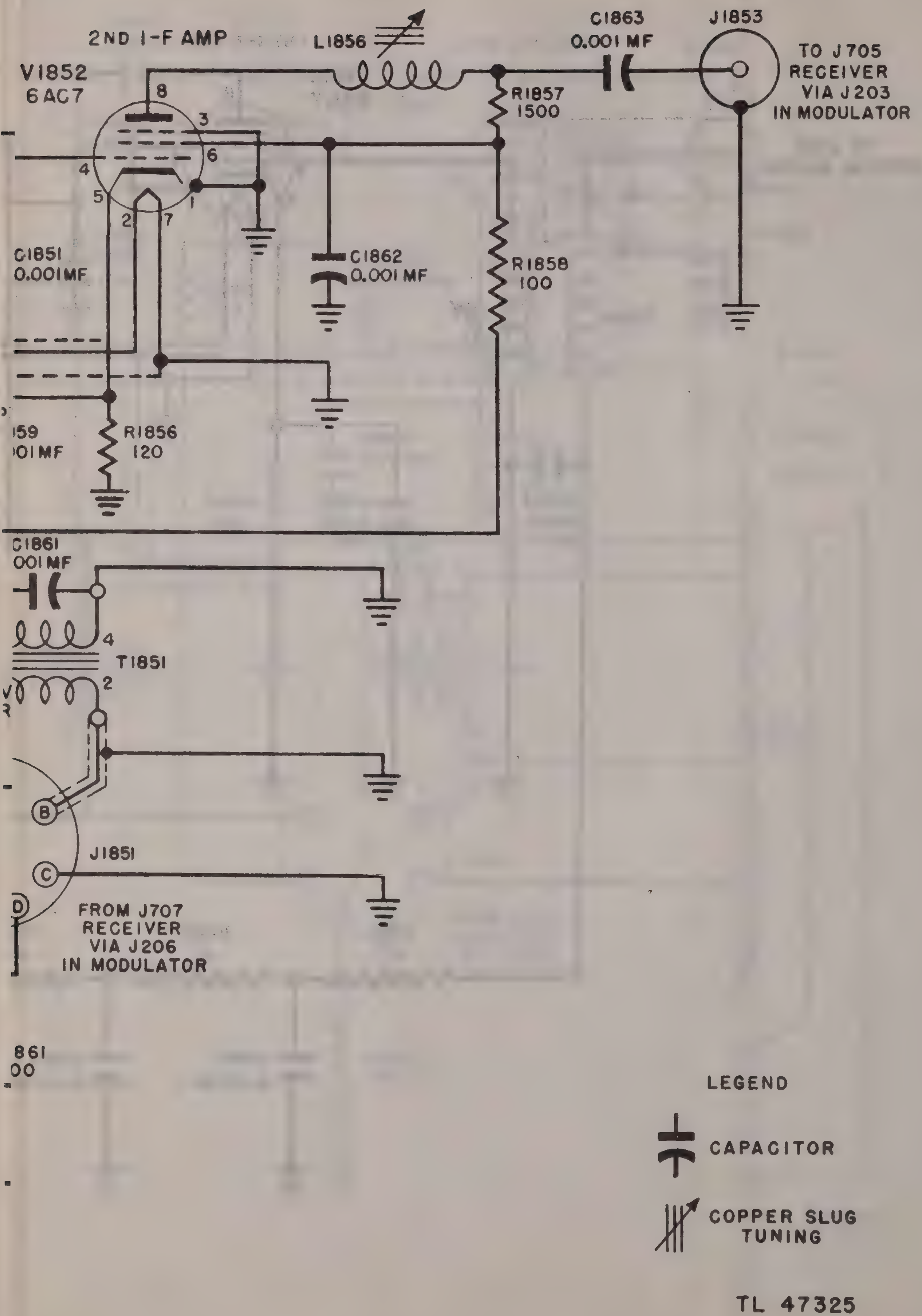

Figure 80. Preamplifier, complete schematic diagram.

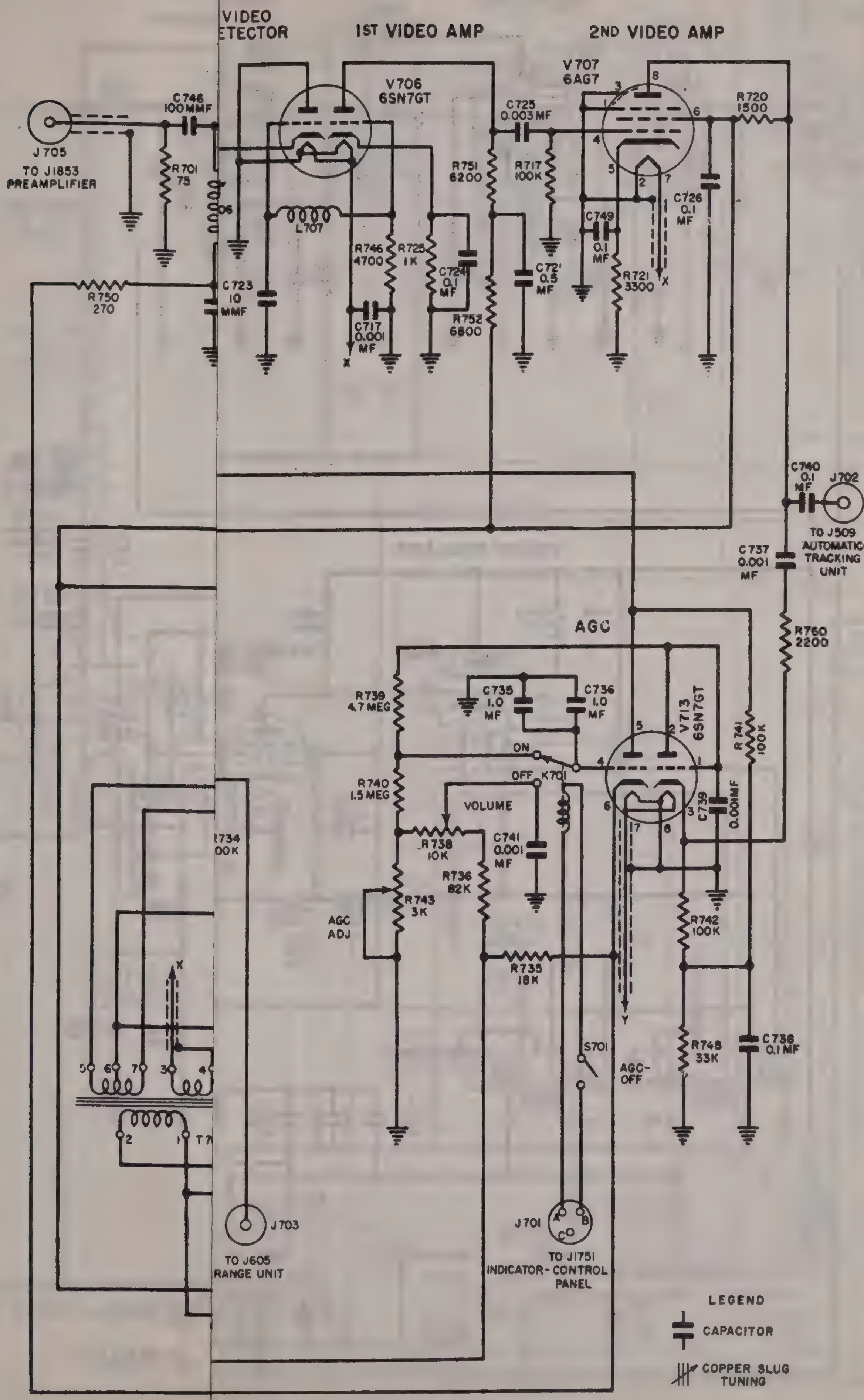

Figure 81. Receiver, complete schematic diagram.

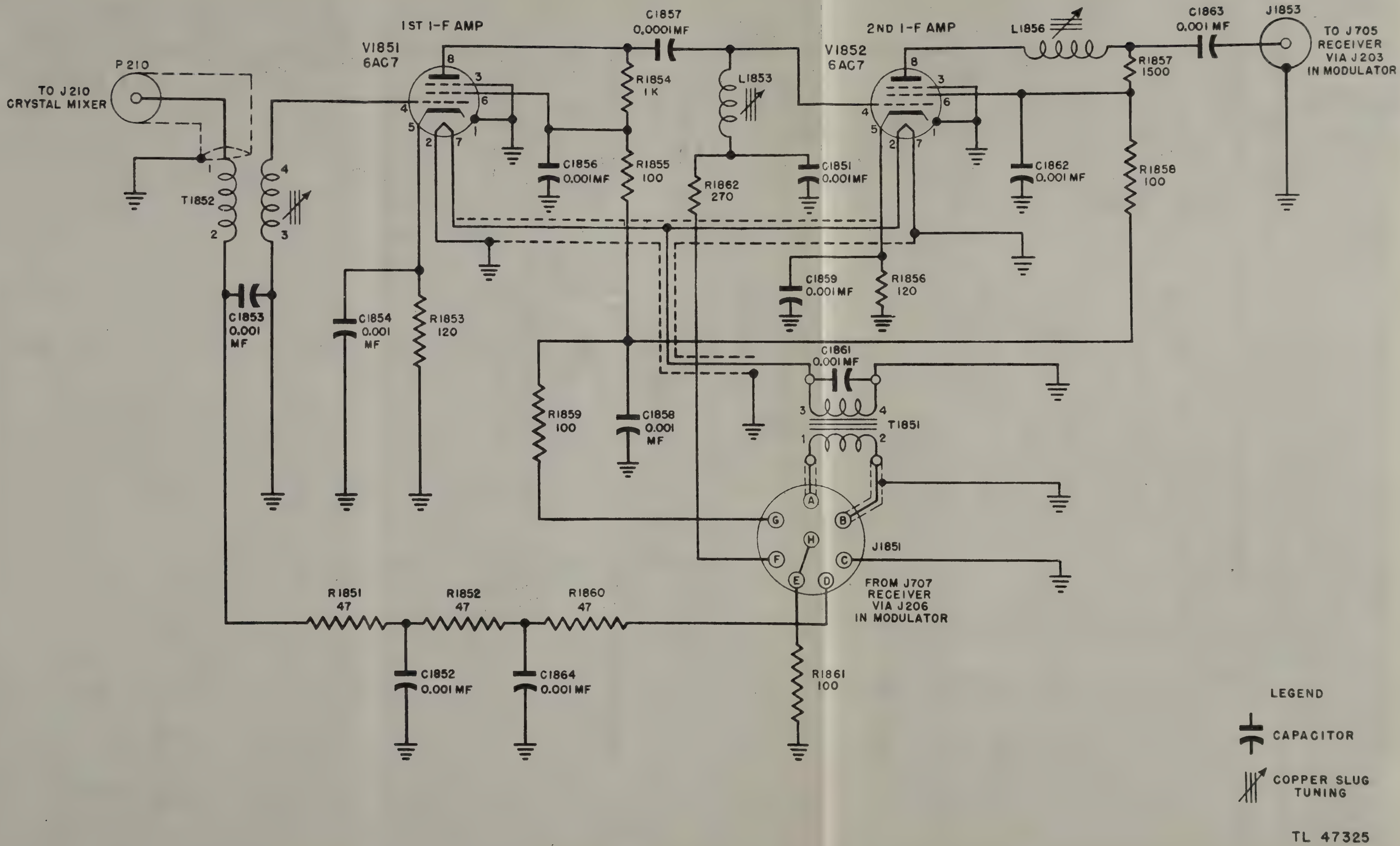

Figure 80. Preamplifier, complete schematic diagram.

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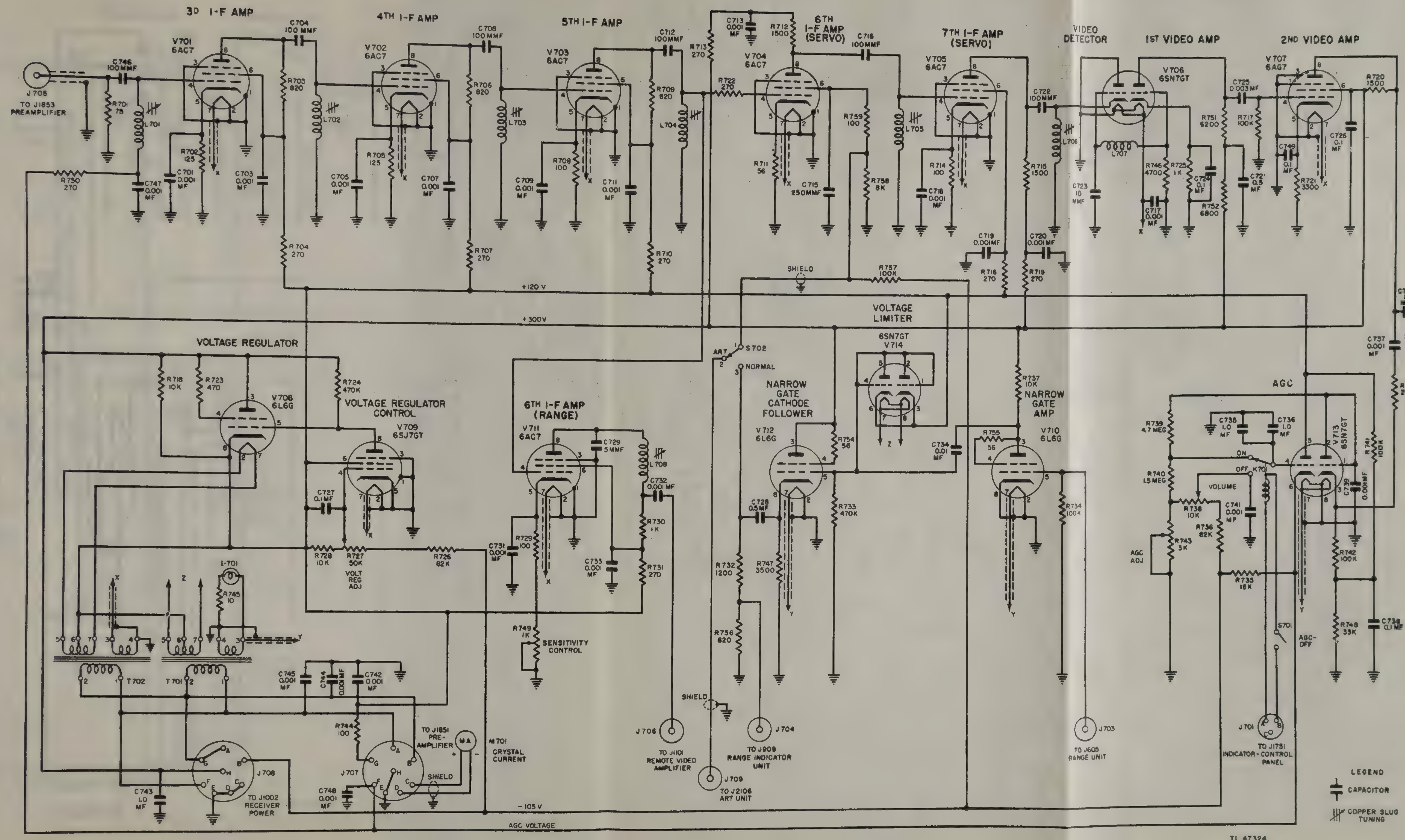

Figure 81. Receiver, complete schematic diagram.

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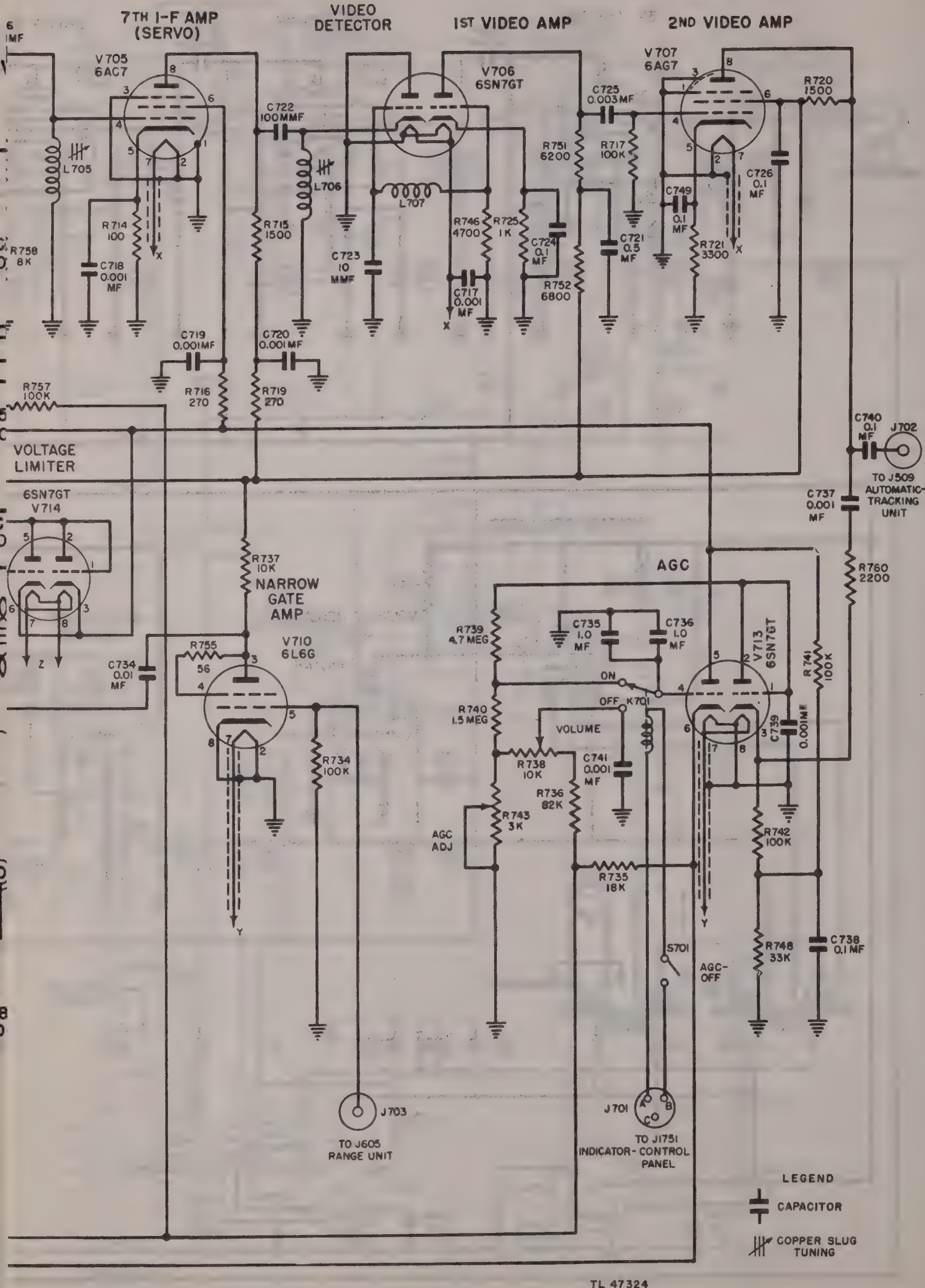

Figure 81. Receiver, complete schematic diagram.

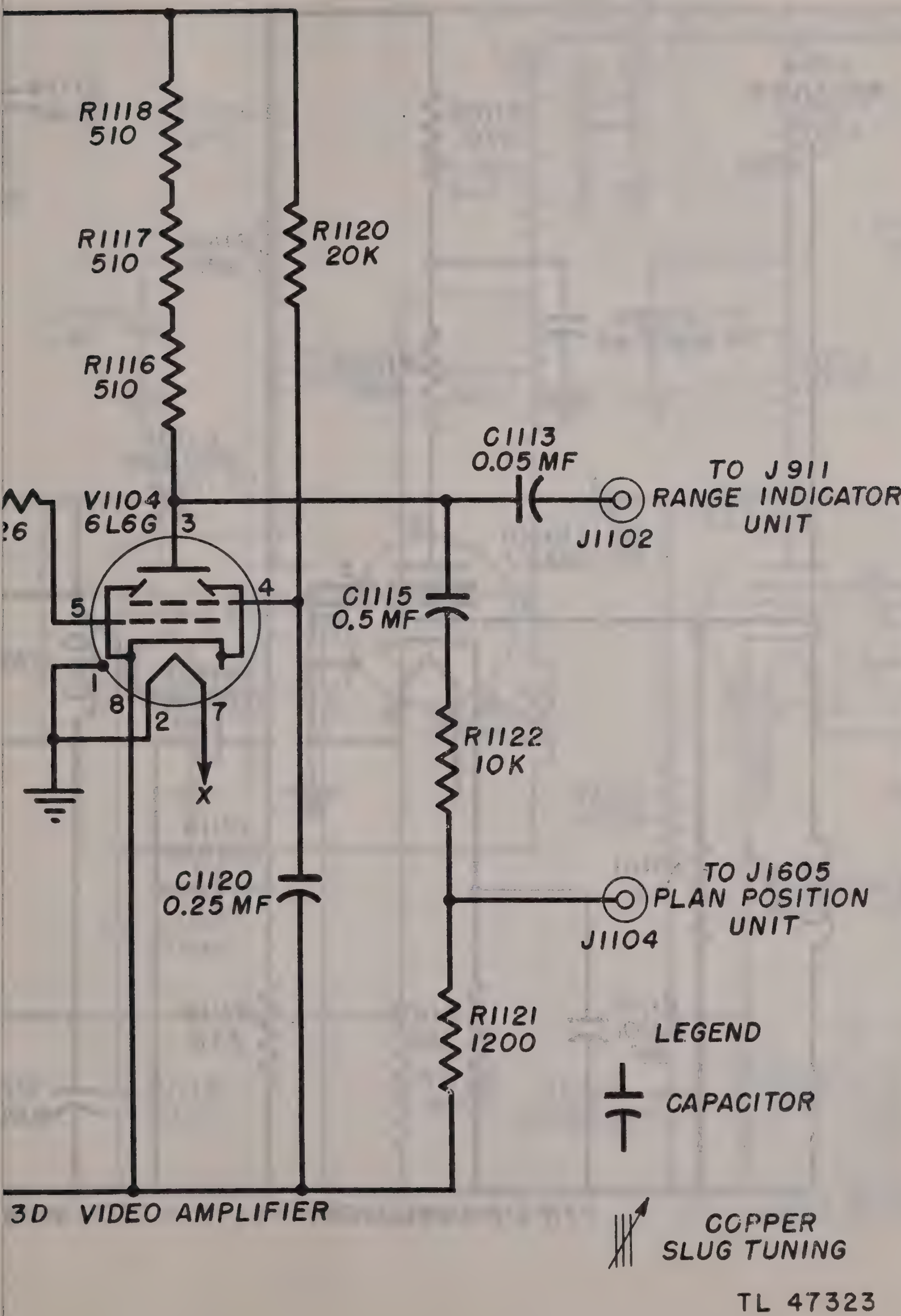

Figure 32. Remote video amplifier, complete schematic diagram.

Figure 81. Receiver, complete schematic diagram.

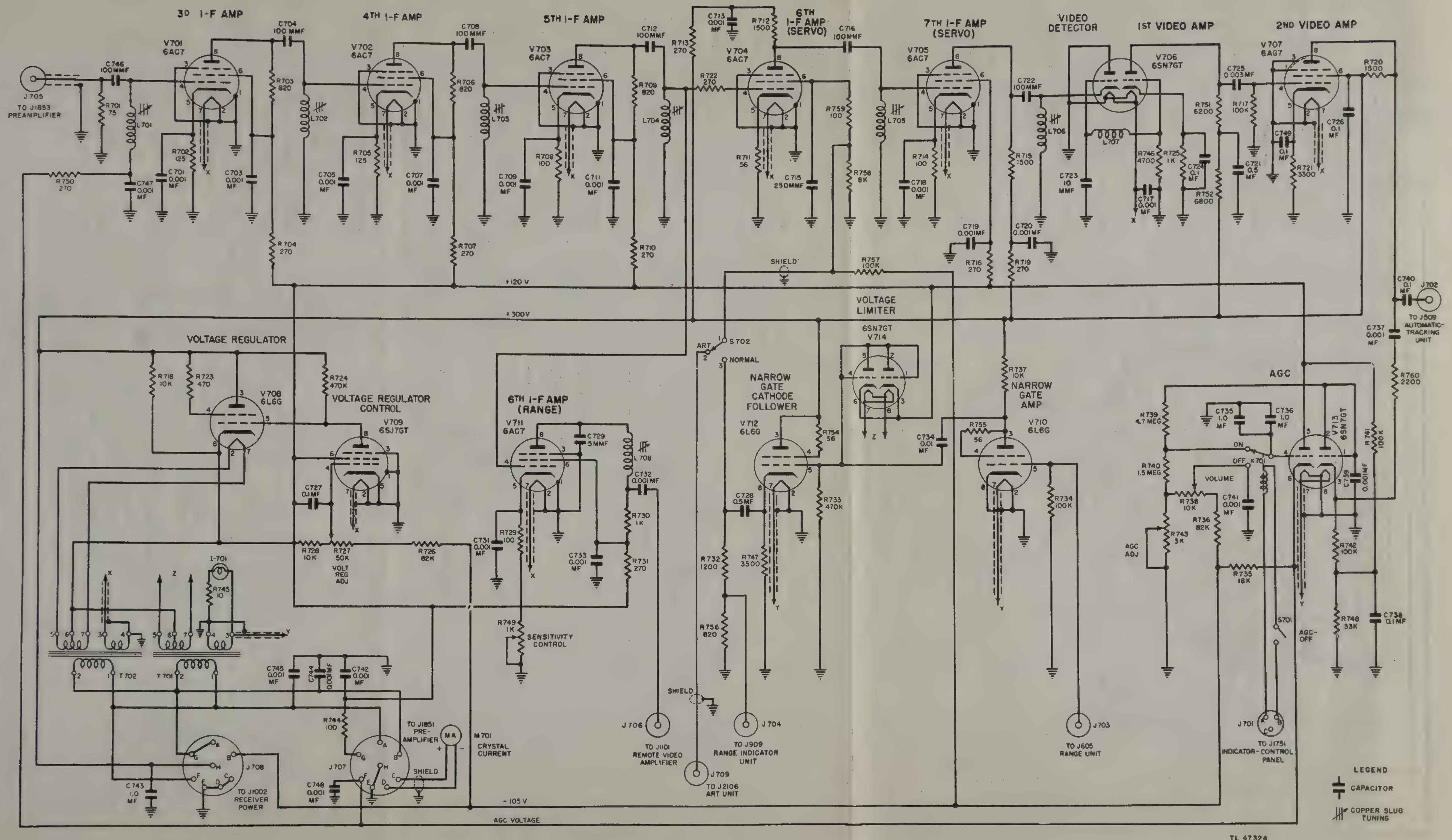

Figure 81. Receiver, complete schematic diagram.

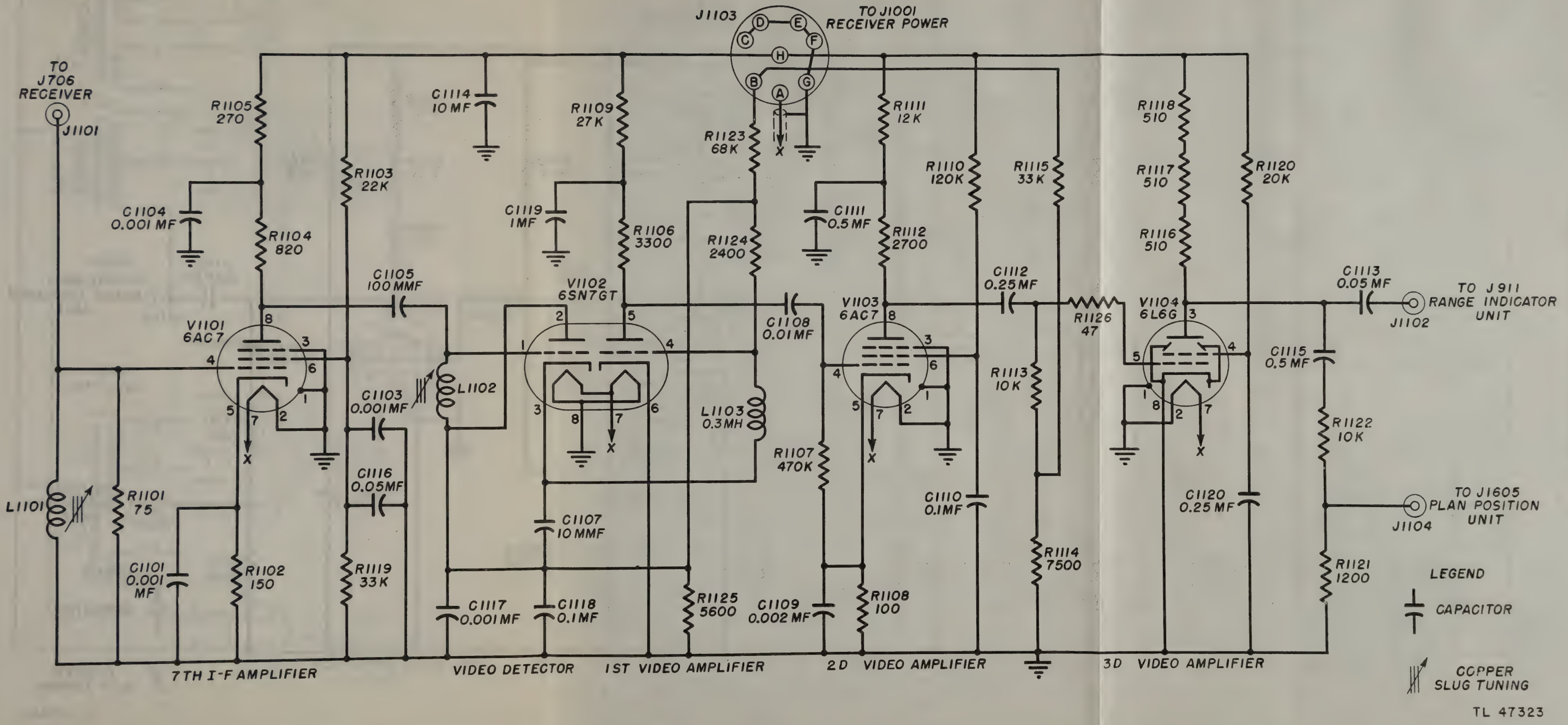

Figure 82. Remote video amplifier, complete schematic diagram.

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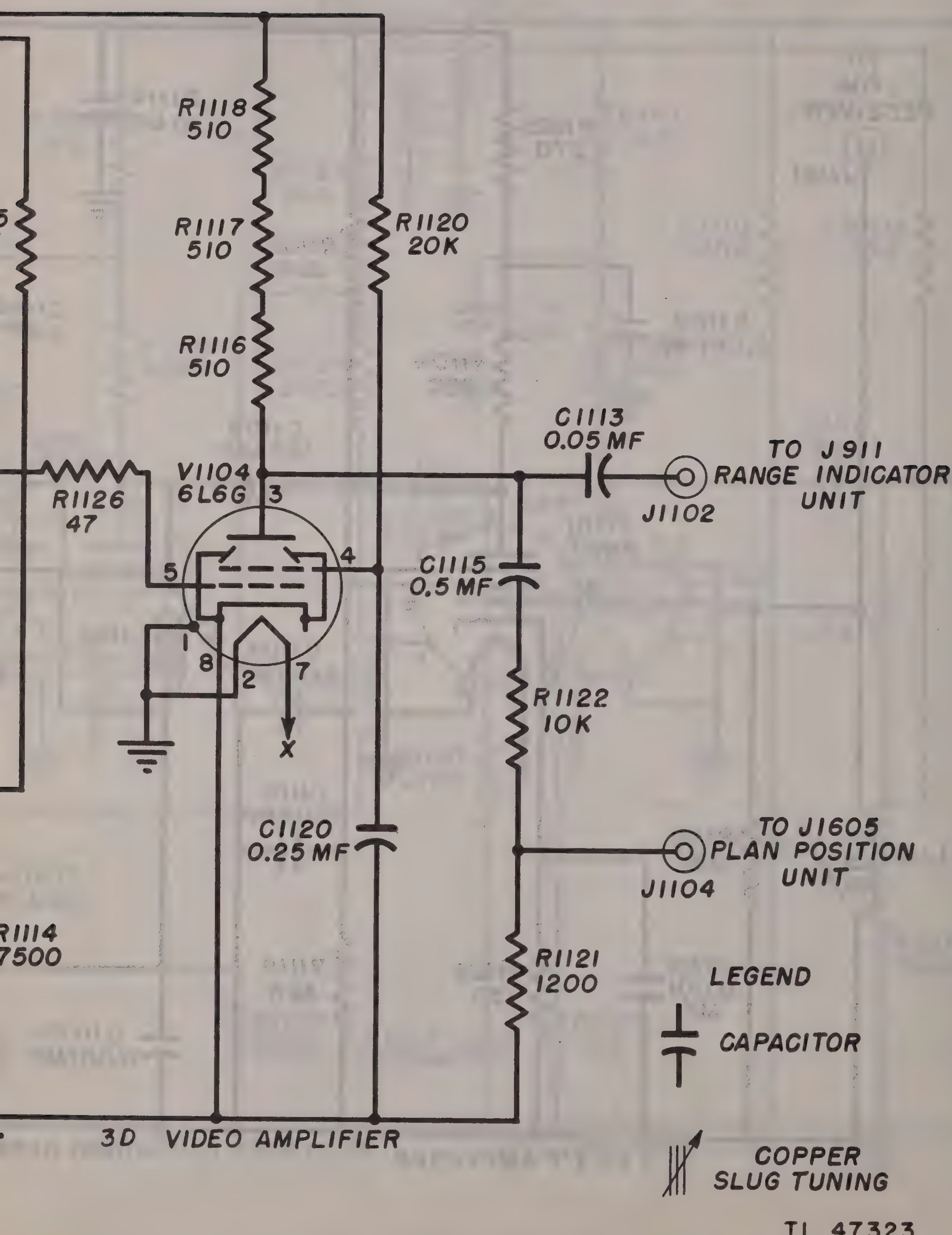


Figure 82. Remote video amplifier, complete schematic diagram.

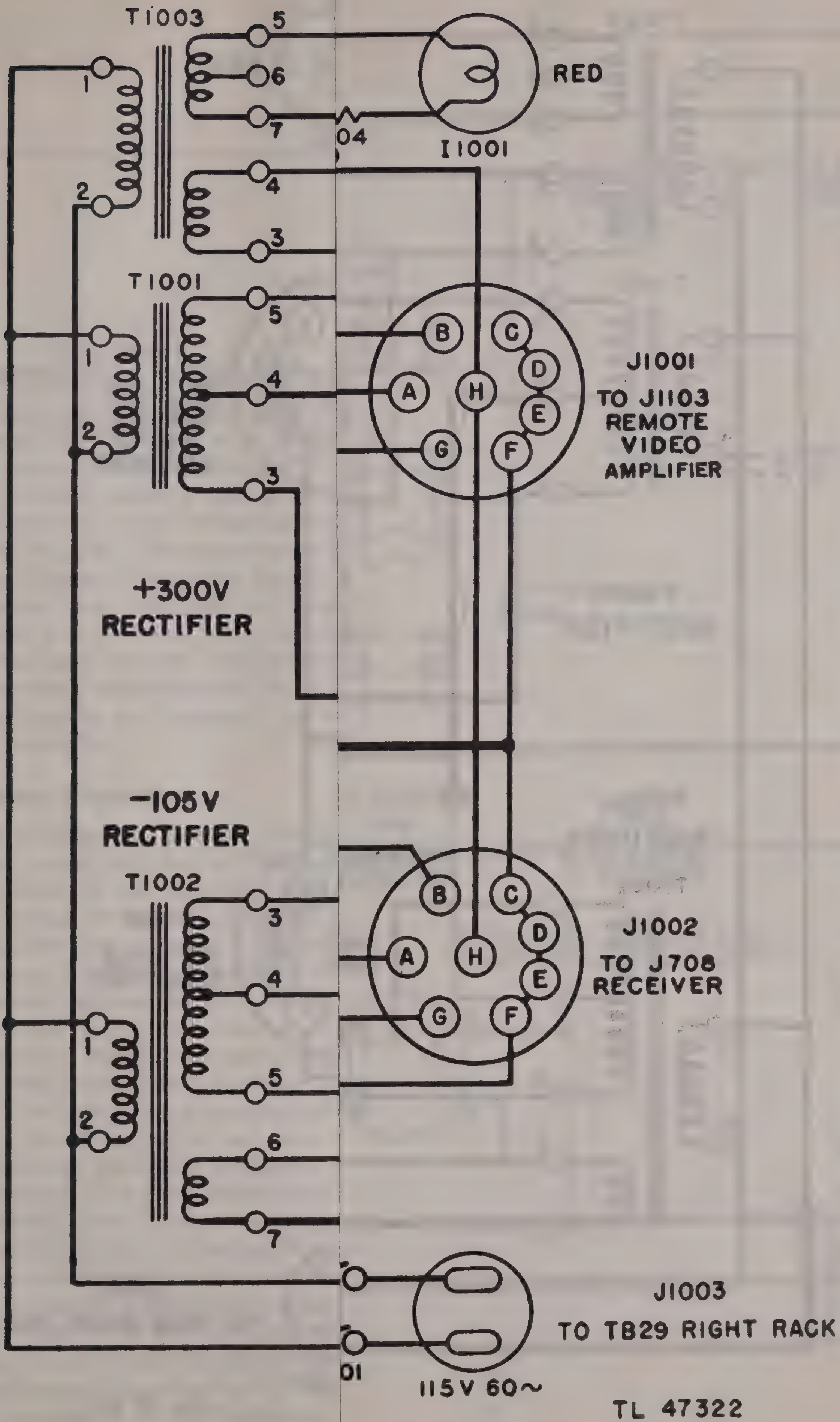


Figure 83. Receiver power supply, complete schematic diagram.

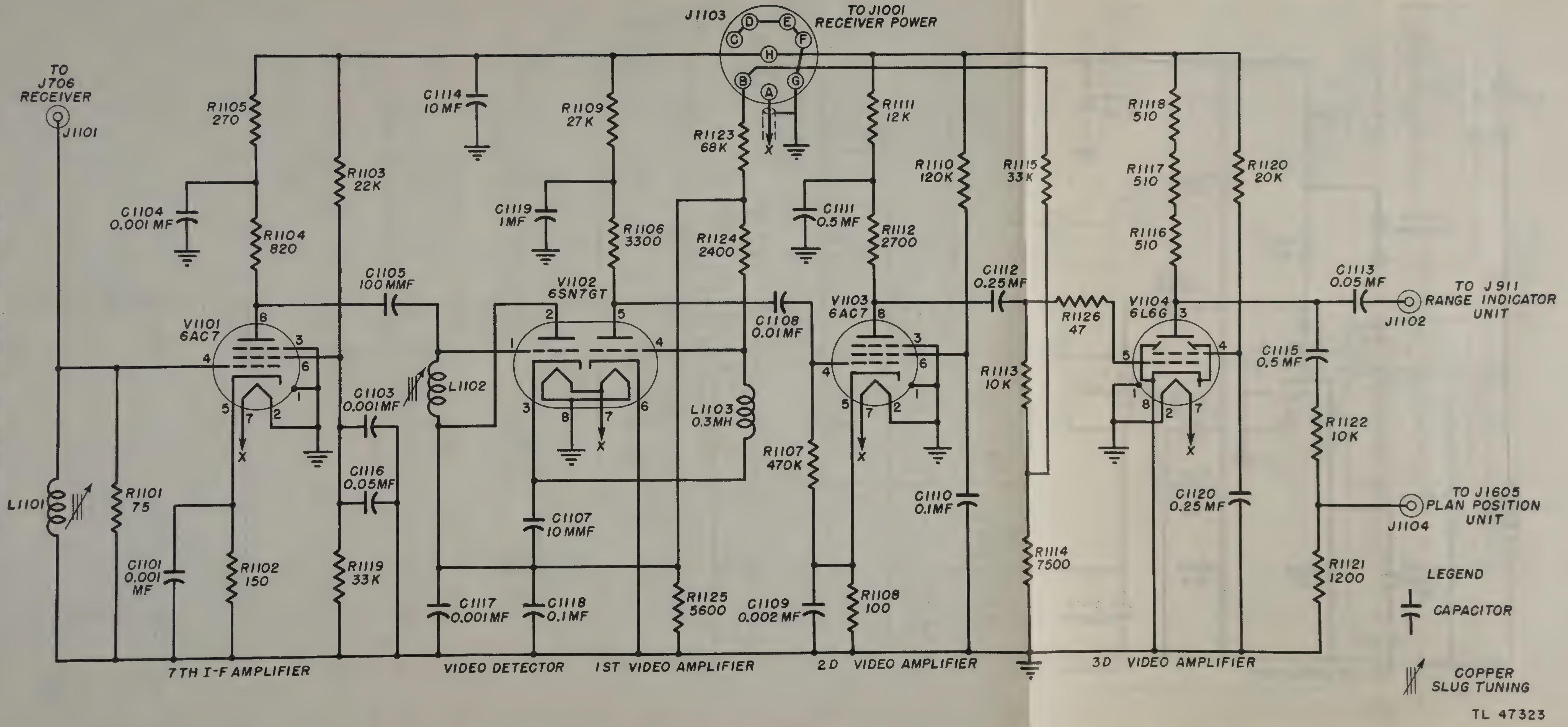


Figure 82. Remote video amplifier, complete schematic diagram.

Figure 82. Remote video amplifier, complete schematic diagram.

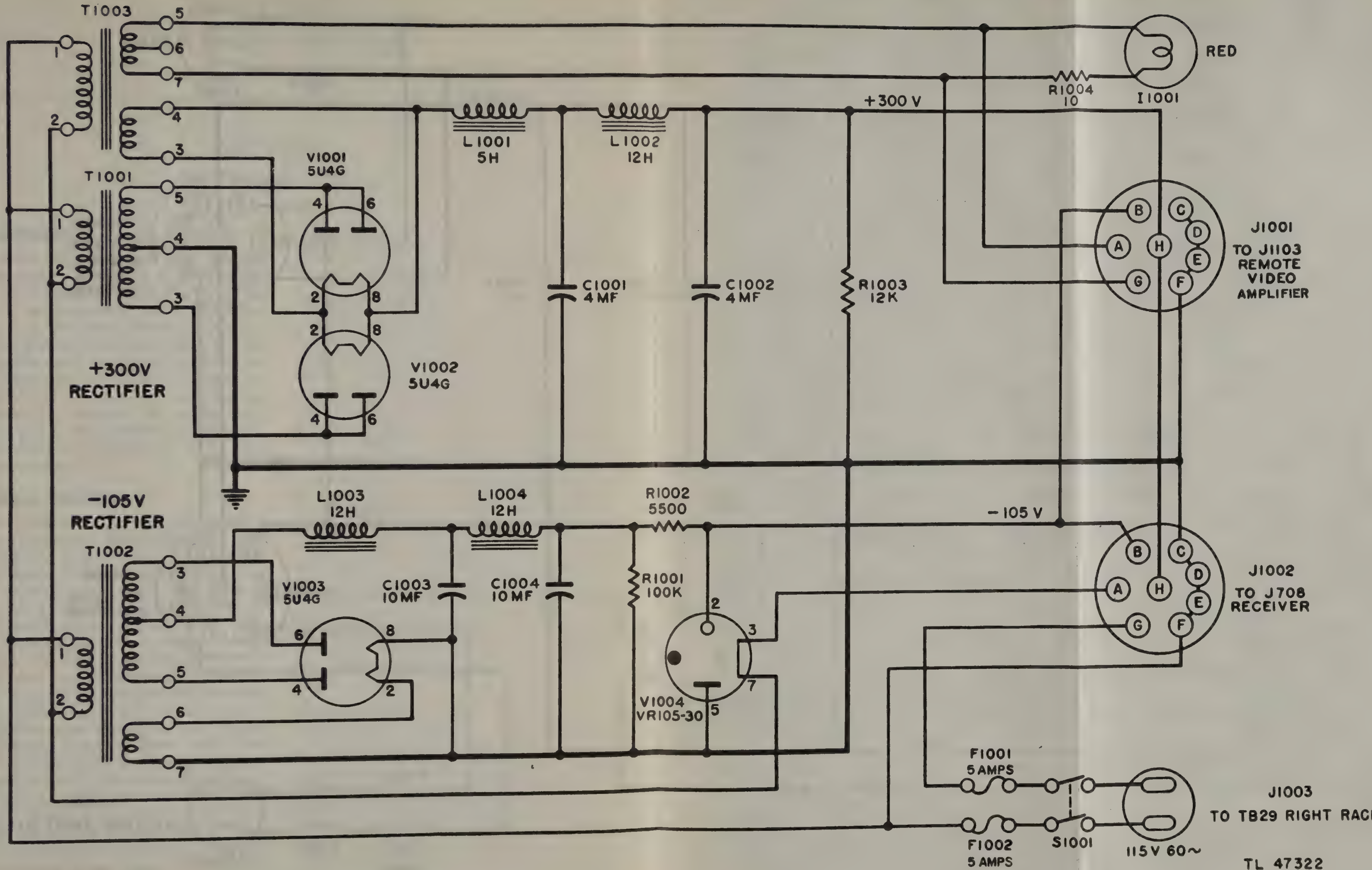


Figure 83. Receiver power supply, complete schematic diagram.

Figure 83. Receiver power supply, complete schematic diagram.

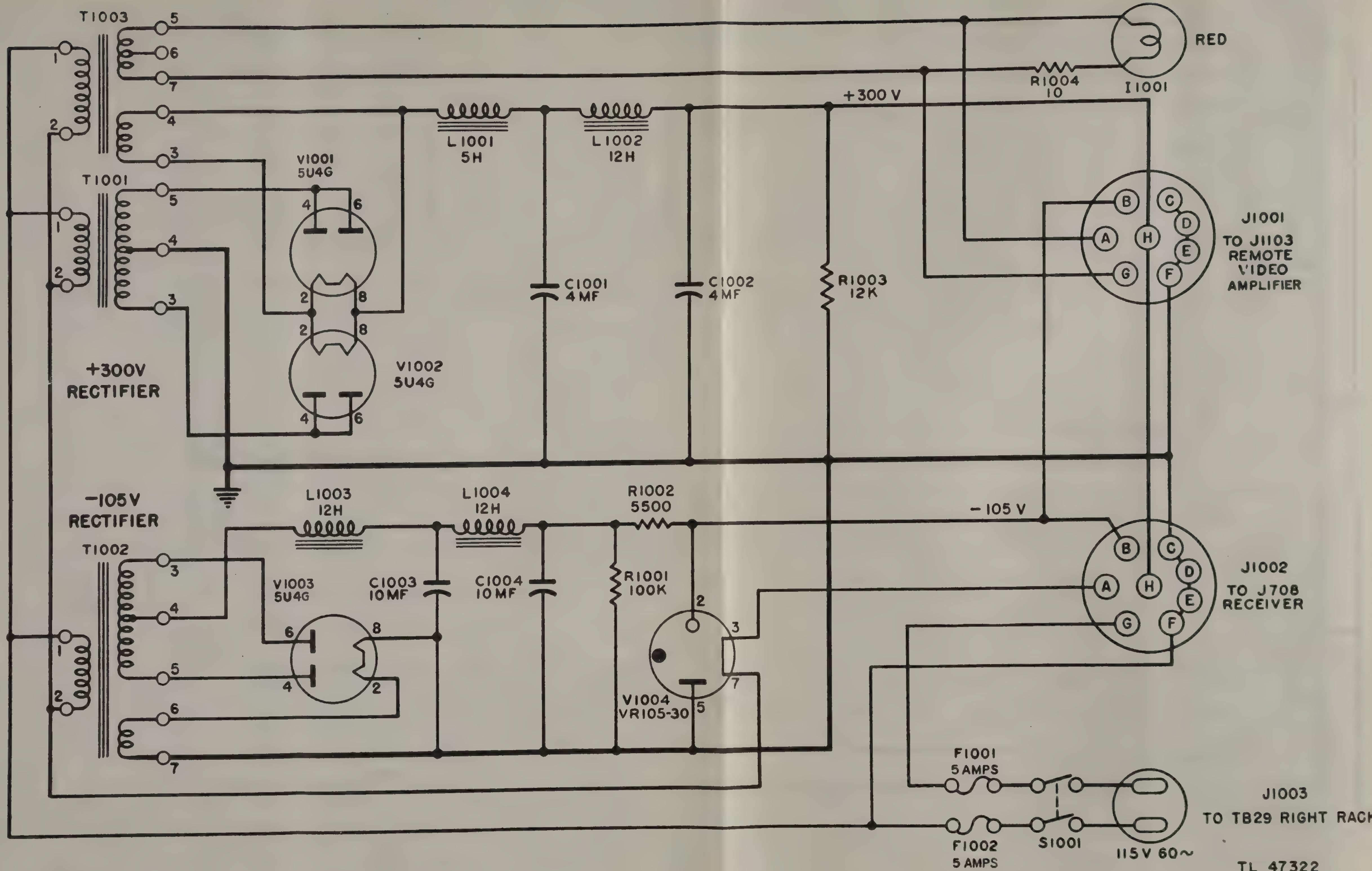


Figure 83. Receiver power supply, complete schematic diagram.

Figure 83. Receiver power supply, complete schematic diagram.

CHAPTER 5
RANGE SYSTEM

SECTION I
INTRODUCTION

84. COMPONENTS IN RANGE SYSTEM.

The range unit (fig. 6), the range indicator unit (fig. 6), the automatic range tracking unit (fig. 7), the range power supply (fig. 7), and the automatic range tracking unit power supply (fig. 7) form the range measuring system of Radio Set SCR-784. The range system presents continuous range-of-target data visually on the range scopes and electrically by selsyns for mechanical gun directors, and potentiometers for electrical gun directors. The components in the range system can be switched for NORMAL operation (narrow gate operation) or for ART (N^2 gate) operation.

85. NORMAL OPERATION.

Figure 84 shows the part the components in the range system play during NORMAL operation. Circuits in the range unit generate the circular sweeps for the coarse and fine range scopes, brighten the trace on the coarse range scope during the 32,000 yards following the transmitter pulse, brighten the trace on the 2,000-yard scope and turn on the receiver servo channel at the time that the selected target echo is being received, and trigger the transmitter and PPI circuits. The targets appear as radial deflections of the circular sweep on the two range scopes. The 32,000-yard scope has a uniform circular scale graduated from 0 to 32,000 yards. The 2,000-yard scope has a circular scale graduated from 0 to 2,000 yards. Rotating hairline pointers are mounted in front of each of the scopes. These pointers are geared so that when the range drive is rotated either by the slewing handwheel or by the range servo drive, the hairline on the 2,000-yard scope makes 16 revolutions for each revolution of the hairline on the 32,000-yard scope. The sweepline on the 2,000-yard scope moves 16 times as fast as the sweep line on the 32,000-yard scope. The development of the sweeps and measurements of target range are shown in figure 86.

86. ART OPERATION.

Figure 85 shows the functions of the circuits in the range system during ART operation. In ART operation the target may be tracked manually by the operator or may be tracked automatically by use of the automatic range tracking unit. The narrow gate to the fine range indicator and the gated receiver channel that was used during NORMAL operation has been replaced by the N^2 gate. Since the N^2 gate is too short to show the position of the target signal on the 2,000-yard scope, a new gate is generated and applied to the 2,000-yard scope to illuminate the trace for 1,800 yards in the vicinity of the target signal. This enables the operator to observe any interfering signals that may be approaching the selected target signal. Range is read in the same manner as during NORMAL operation, and the appearance of the range scopes differs only in that the fine range scope sweep trace is visible for 1,800 yards and the N^2 gate appears as a bright spot at the leading edge of the selected signal.

87. AUTOMATIC RANGE TRACKING.

Range tracking may be made automatic during ART operation by using circuits in the automatic range tracking unit to keep the N^2 gate at the same range as the selected target signal, and to keep the range indicator hairlines at the same range as the N^2 gate signal. The appearance of the indicator is the same during ART operation whether automatic range tracking is used or not, the only difference being that no attention is required of the operator to track a target and to give continuous range data.

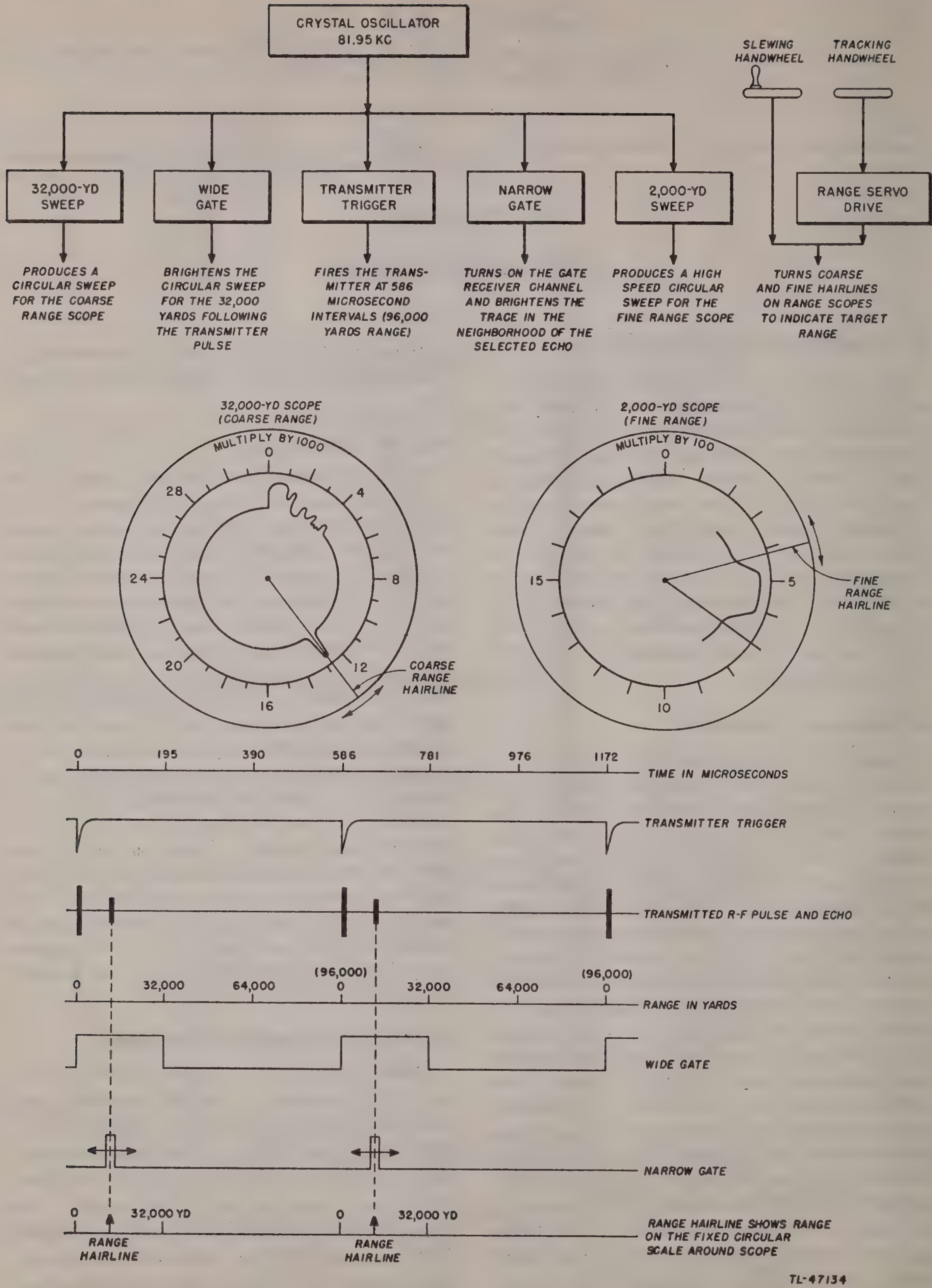


Figure 84. Range system, normal operation.

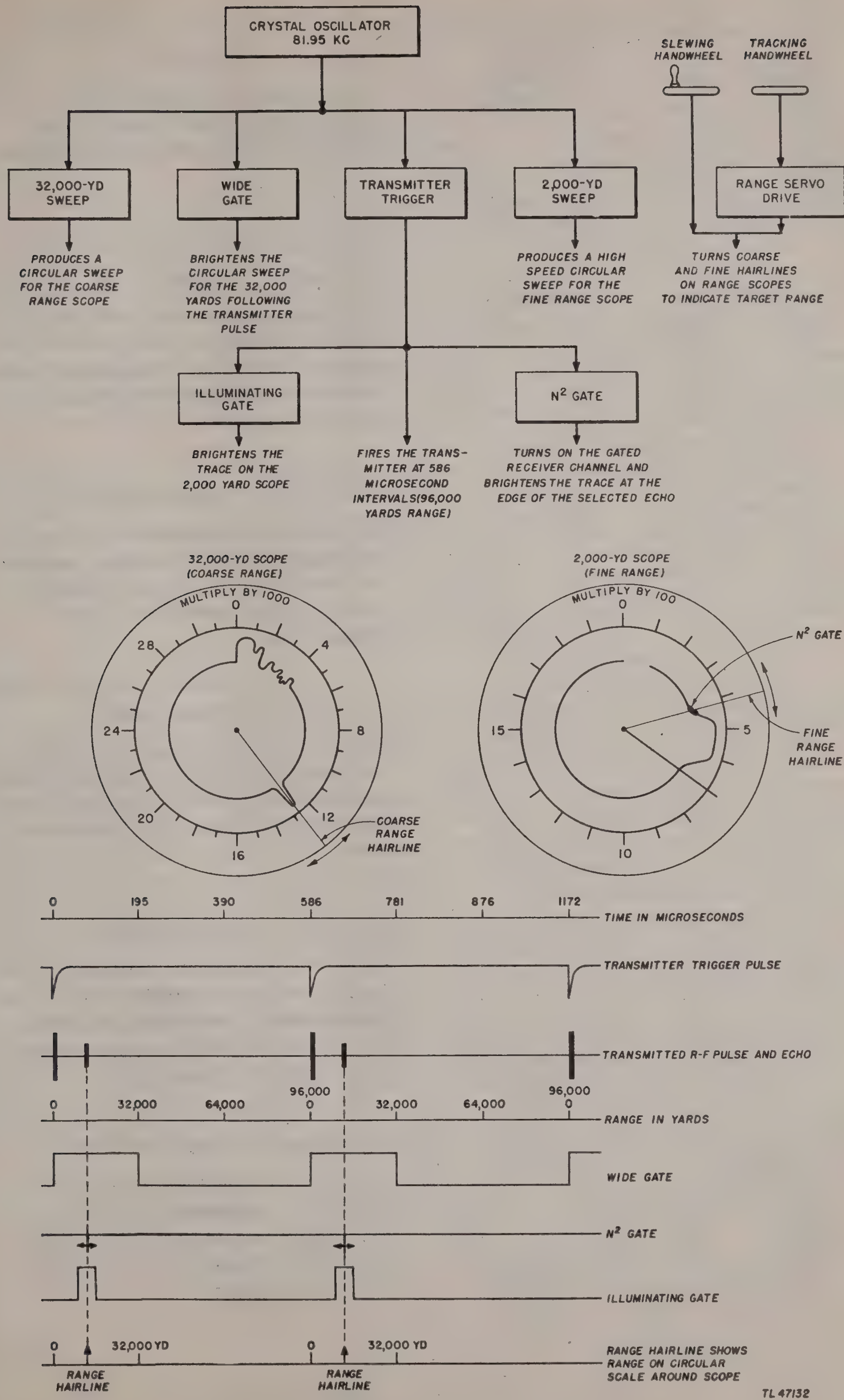
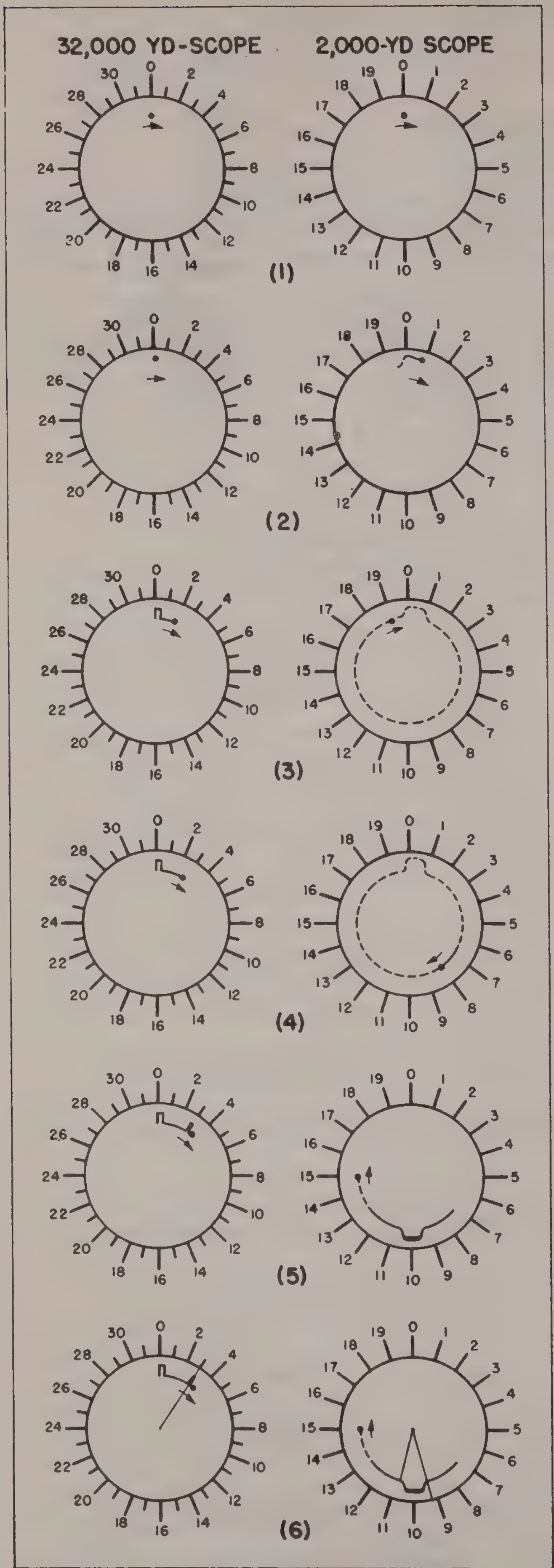


Figure 85. Range system, ART operation.



T=0 RANGE=0

JUST BEFORE THE TRANSMITTER PULSES. BOTH SPOTS ARE AT THE TOP CENTER AND MOVING CLOCKWISE.

T=0.5 μSEC RANGE = 80 YD

THE TRANSMITTER HAS NOT YET STOPPED PULSING. THE SPOT ON THE 2000-YD SCOPE HAS MOVED 16 TIMES AS FAR AS THE SPOT ON THE 32,000-YD SCOPE.

T=11.6 μSEC RANGE = 1900 YD

THE COMPLETE TRANSMITTER PULSE HAS BEEN TRACED ON BOTH SCOPES. THE SPOT ON THE 2000-YD SCOPE HAS ALMOST COMPLETED ONE REVOLUTION.

T=17.1 μSEC RANGE = 2800 YD

THE SPOT ON THE 2000-YD SCOPE HAS MADE ALMOST 1-1/2 REVOLUTIONS. THE LAST 150 YARDS IS BRIGHTENED BY THE BEGINNING OF THE NARROW GATE.

T=21.4 μSEC RANGE = 3500 YD

AN ECHO HAS BEEN RECEIVED AND TRACED BY BOTH SCOPES. THE NARROW GATE HAS ENDED SO THAT THE TRACE ON THE 2000-YD SCOPE IS NO LONGER BRIGHT.

T=21.4 μSEC RANGE = 3500 YD

THIS IS THE SAME AS THE PRECEDING SNAPSHOT EXCEPT THAT THE RANGE HAIRLINES HAVE BEEN ADDED. THE RANGE OF THE TARGET IS 2920 YARDS.

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Figure 86. Development of circular sweep.

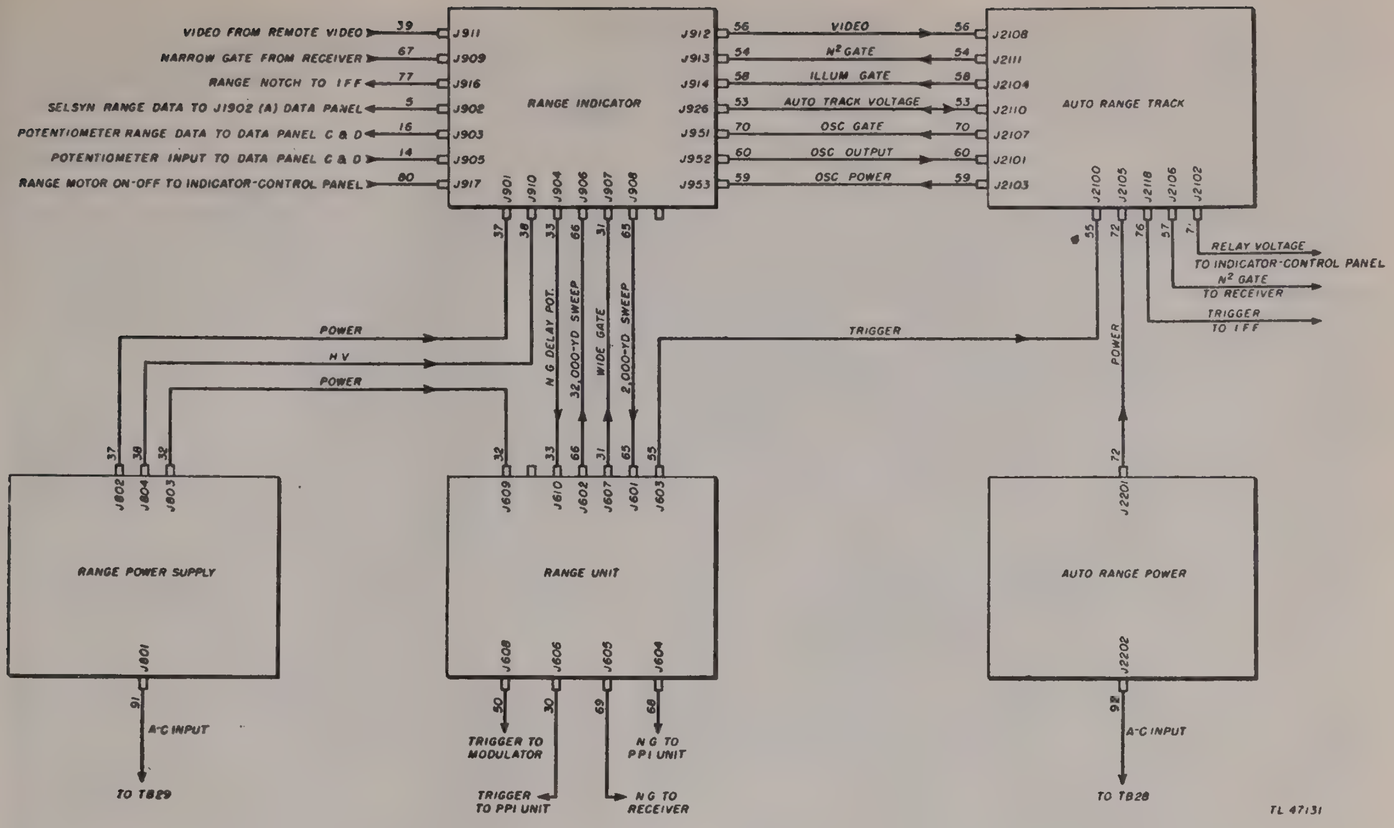


Figure 87. Range system, cabling.

88. RANGE SYSTEM CABLING.

The cabling of the range system is shown in figure 87. This diagram shows the cable numbers and the signals that each cable carries.

a. The change from NORMAL to ART or from ART to NORMAL operation is made by throwing the switches back of the receiver, range unit, and range indicator to the desired position.

(*1*) When the switches are in the NORMAL positions:

(*a*) The narrow gate from the range unit is applied to the receiver through switch S602 of the range unit.

(*b*) The narrow gate is applied to the 2,000-yard scope through switch S904 of the range indicator.

(*c*) The narrow gate is applied to the 6th i.f. in the receiver through switch S702 of the receiver.

(*2*) When the switches are in the ART position:

(*a*) The trigger is applied to the automatic range tracking unit through switch S602 of the range unit.

(*b*) The illuminating gate is applied to the 2,000-yard scope through switch S904 of the range indicator.

(*c*) The N^2 gate is applied to the 6th i.f. in the receiver through switch S702 of the receiver.

b. The change from manual to automatic or automatic to manual range tracking is made by throwing the TRACKING SWITCH on the indicator-control panel to the position desired.

SECTION II

RANGE UNIT

89. BLOCK DIAGRAM.

The crystal oscillator, 32,000- and 2,000-yard sweeps, wide gate, narrow gate, and trigger stages shown in figure 84 are located in the range unit (figs. 88 and 89). The circuits that make up these stages are shown in the complete block diagram in figure 90, and the time relationship of their outputs is shown in figure 91.

a. Crystal Oscillator. The crystal oscillator used for frequency control of the range unit produces very stable 81.95-kc oscillations. This oscillator output is the timing voltage for the radar set. Proper operation of the entire radar set depends on the action of this stage; a small frequency deviation is sufficient to cause distortion of all the output voltages.

b. 2,000-yard Sweep Transformer. The output of the crystal oscillator is applied to the sweep transformer where two voltages, 90 degrees out-of-phase, are induced in the two output windings. These voltages, when applied simultaneously to the deflection plates of the fine range indicator tube, develop a 2,000-yard circular timebase or sweep.

c. Trigger Generator. The crystal oscillator output is also coupled to the trigger generator. This stage distorts the sine wave, producing a peaked waveform. This trigger output is fed to the trigger selector stage (where one out of every 48 peaks is used as a trigger) and to the 20.49-kc frequency-dividing multivibrator.

d. 20-kc Multivibrator. The 20-kc multivibrator operates at 20.49 kc and is used only as a frequency-dividing multivibrator to synchronize the 5-kc multivibrator. Exact division of the crystal frequency is essential because most of the actions taking place in the radar set depend on synchronization. Instability would cause the

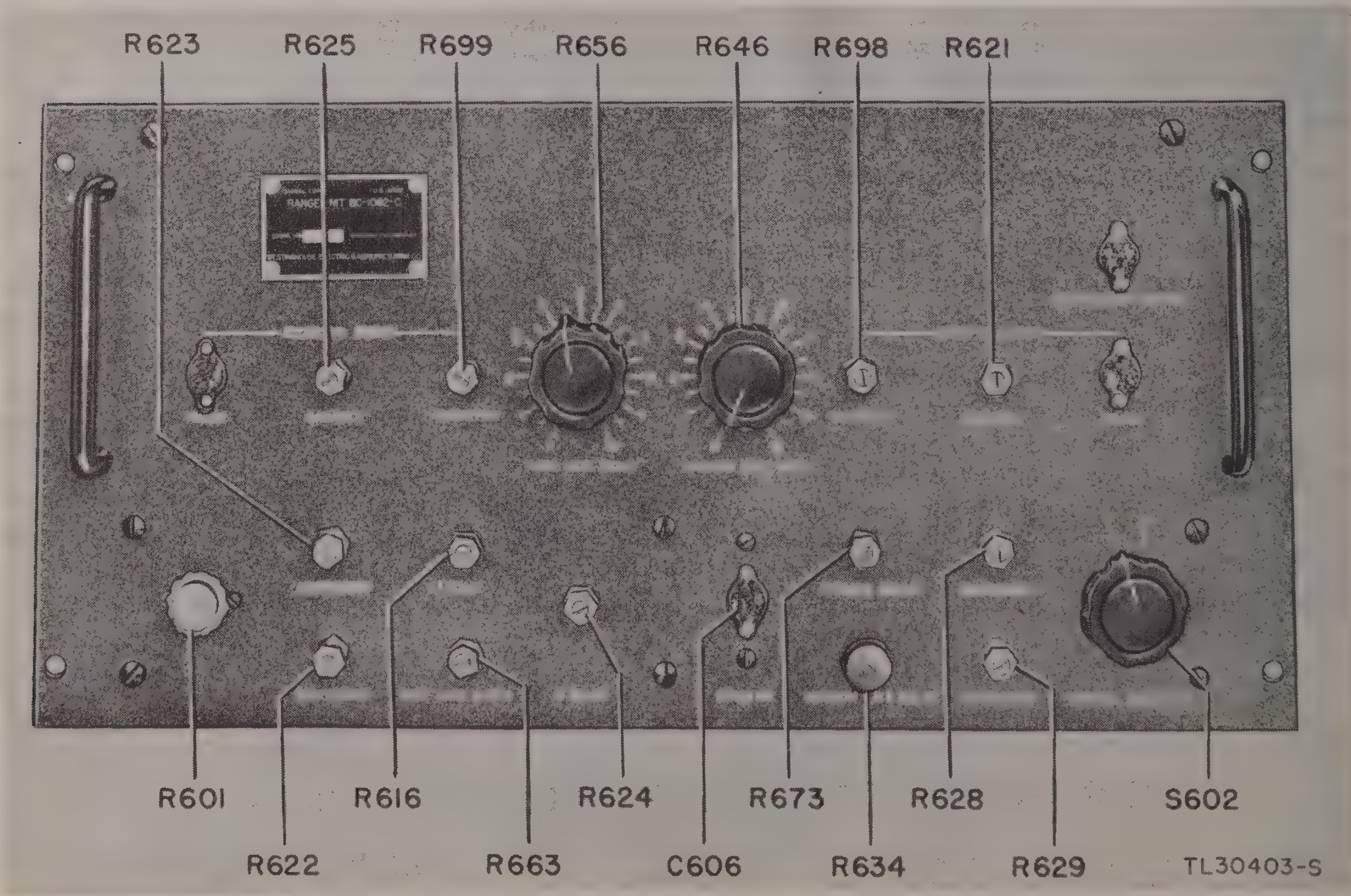


Figure 88. Range unit, front view.

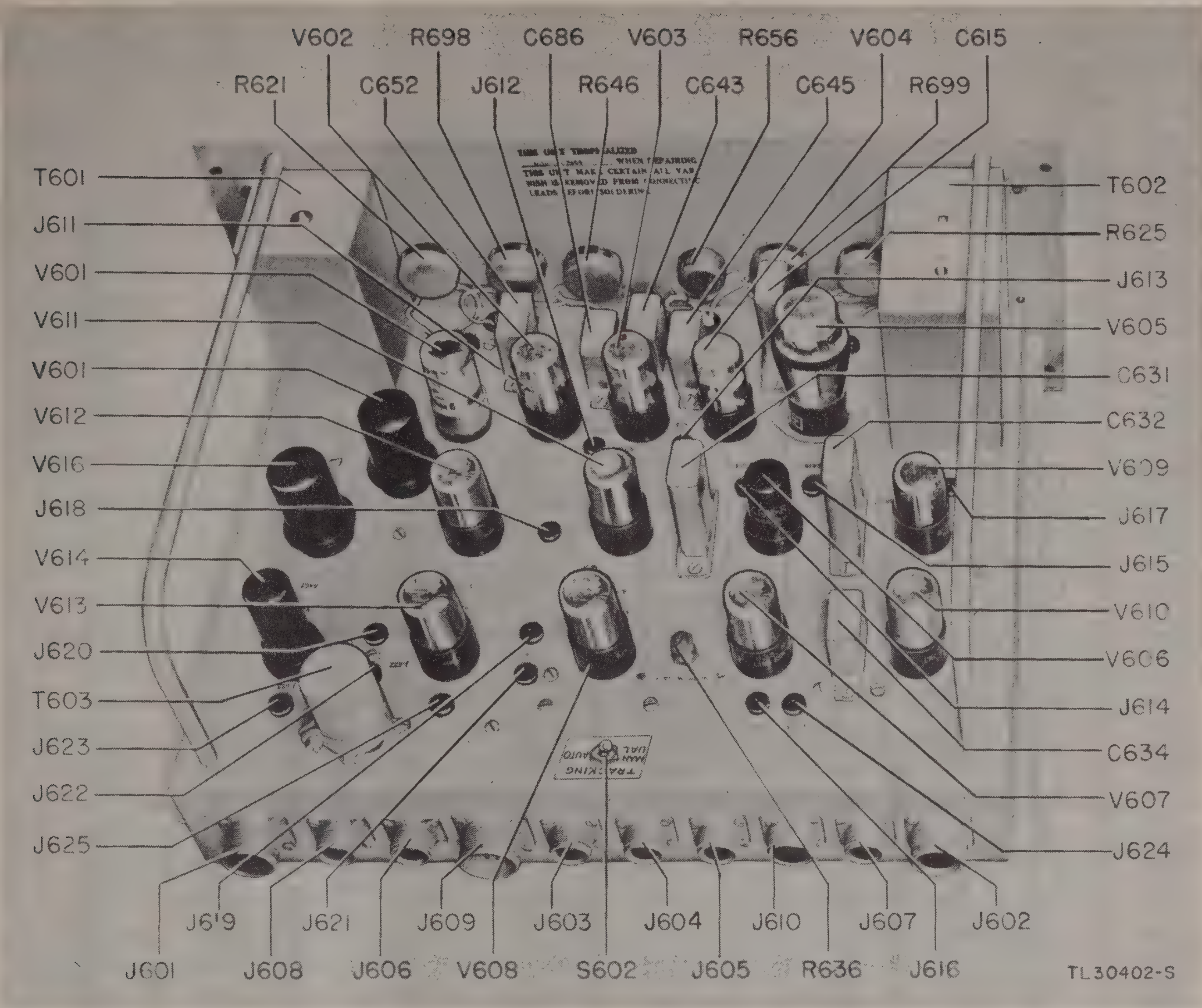


Figure 89. Range unit, top view.

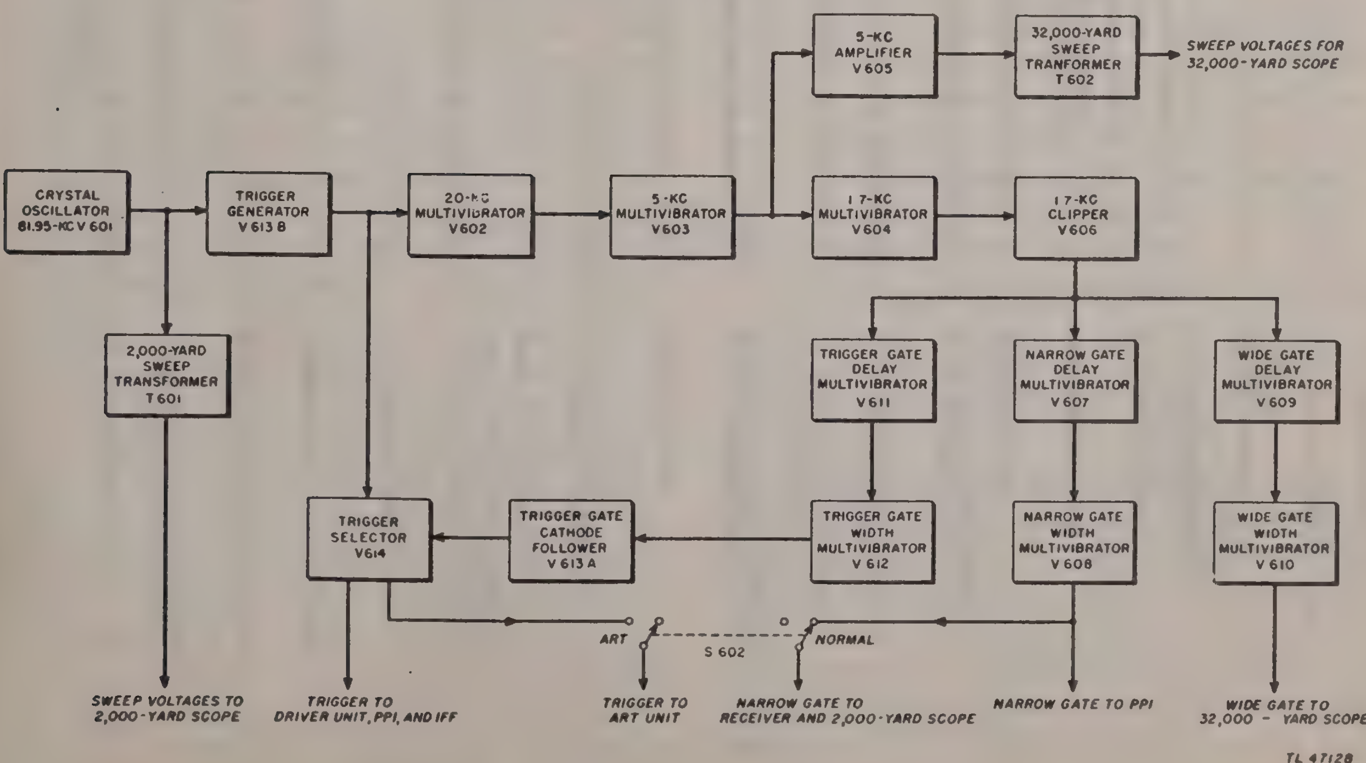


Figure 90. Range unit, complete block diagram.

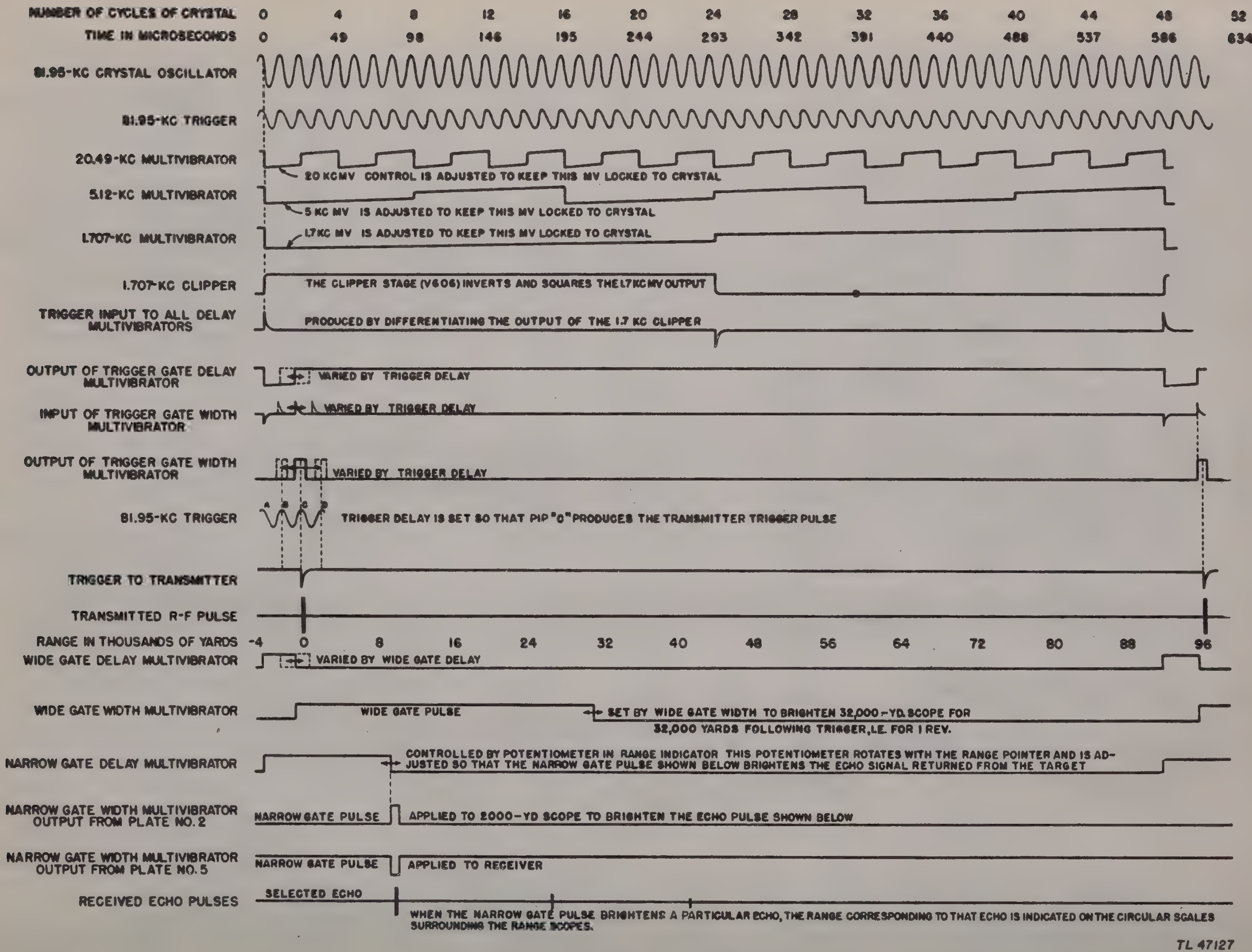


Figure 91. Range unit, waveforms.

transmitter to fire irregularly and the sweeps on the scopes would be blurred. If it were possible to design a stable multivibrator which would divide the crystal frequency directly by 16, the 20-kc multivibrator would be unnecessary. The required stability, however, is attained by making the division in two stages.

e. 5-kc Multivibrator. The 5-kc multivibrator operates at 5.12 kc and is synchronized by the output of the 20-kc multivibrator. Every fourth cycle of the 20-kc wave triggers the 5-kc multivibrator, and locks the stage to this repetition frequency. Two outputs are obtained from the 5-kc multivibrator, one triggers the 1.7-kc multivibrator, the other feeds the 5-kc amplifier.

f. 5-kc Amplifier. The 5-kc amplifier stage is tuned to 5.12 kilocycles. Its function is to remove the harmonics associated with the square wave input. The fundamental 5.12-kc frequency is then used to feed the phase splitting transformer T602.

g. 32,000-yard Sweep Transformer. The 32,000-yard sweep transformer is similar to the 2,000-yard transformer. Two sine-wave voltages, 90 degrees out-of-phase, are produced and are applied simultaneously to the scope, developing a 32,000-yard circular timebase.

h. 1.7-kc Multivibrator. Every third cycle of the 5-kc multivibrator output triggers the 1.7-kc multivibrator which operates at 1.707 kc. This multivibrator determines the trigger, or basic recurrence frequency of the SCR-784.

i. 1.7-kc Clipper. The output from the 1.7-kc multivibrator is fed to the 1.7-kc clipper. This is an overdriven amplifier which inverts the pulse and steepens the side of the square wave. The more nearly the wave approaches a true square wave, the more exact is the timing of the circuits which are controlled by this square wave. The output of this stage triggers the narrow, wide, and trigger gate delay multivibrators.

j. Narrow Gate Delay Multivibrator. The purpose of the narrow gate delay multivibrator is to produce from the 1.7-kc clipper pulse another pulse which can be delayed by an amount controlled by the setting of the range potentiometer. This delayed pulse is used to trigger the narrow gate width multivibrator.

k. Narrow Gate Width Multivibrator. The narrow gate width multivibrator is triggered by the back or lagging edge of the narrow gate delay multivibrator output, and produces a pulse which lasts for an interval of time determined by the setting of the narrow gate width control. The narrow gate is made to occur at the time corresponding to the range of the selected target. This signal is applied to:

(*1*) The 2,000-yard scope as a brightening pulse (during NORMAL operation only) through the receiver narrow gate amplifier and cathode follower.

(*2*) The receiver as a gating pulse (during NORMAL operation only).

(*3*) The PPI, to indicate the working range.

l. Trigger Gate Delay Multivibrator. The purpose of the trigger gate delay multivibrator is to delay the transmitted pulse so that the transmitter does not fire until the narrow gate delay multivibrator operation has reached the linear stage. This makes the range measuring system stable down to zero range.

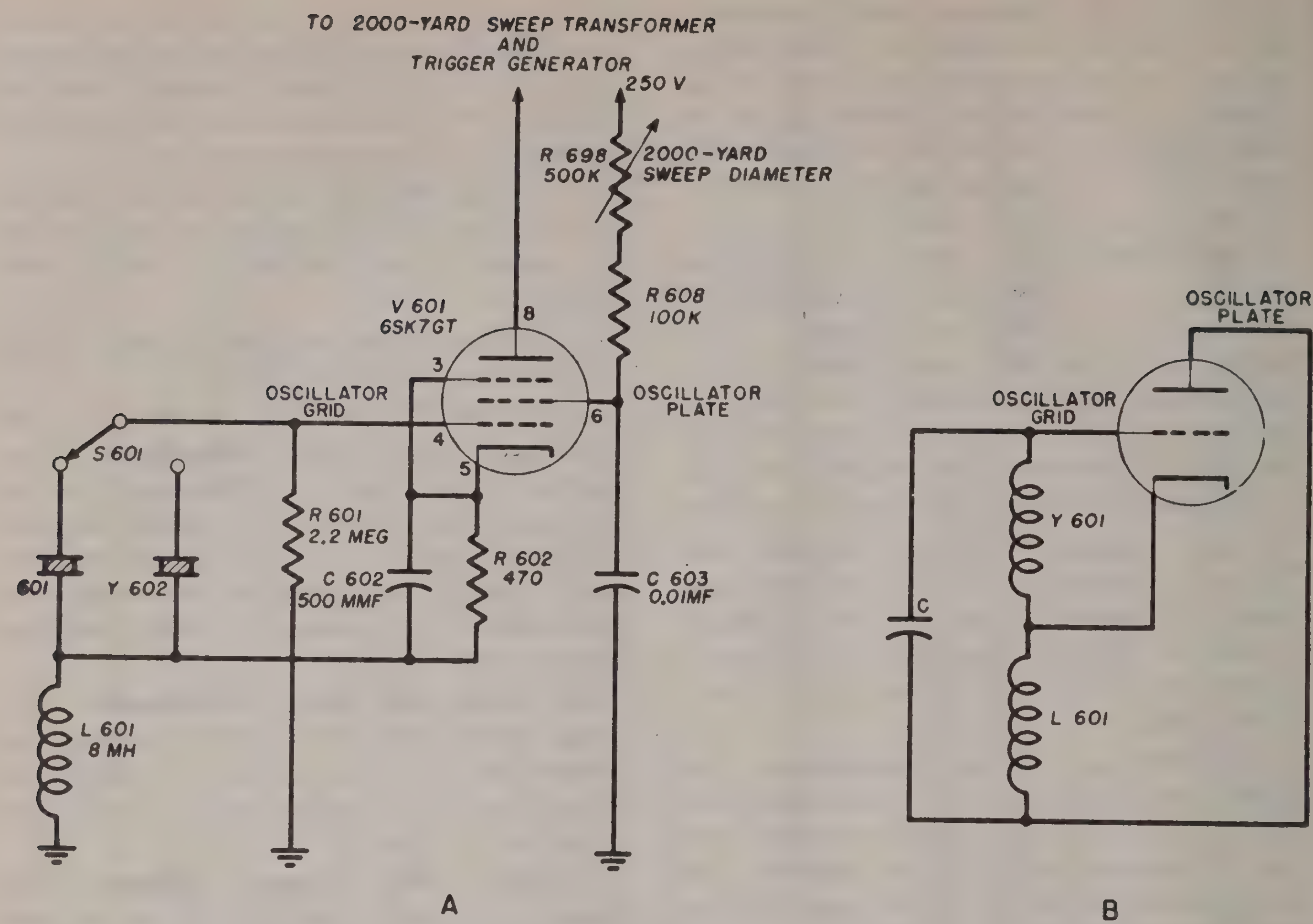
m. Trigger Gate Width Multivibrator. The trigger gate width multivibrator generates the trigger selector gate. The start of this gate is determined by the output of the trigger gate delay multivibrator.

n. Trigger Gate Cathode Follower. The trigger gate pulse is fed to the trigger gate cathode follower. The function of this stage is to make the 6-microsecond pulse available from a low impedance source for application to the trigger selector stage.

o. Trigger Selector. The trigger selector stage acts as a control switch to select one out of every 48 of the 81.95-kc pips, the selected pip being the one that triggers the transmitter and the other synchronized components in the radar set. The outputs from the trigger generator and the trigger gate cathode follower combine to select the pulse that triggers the transmitter, PPI, and IFF after the narrow gate delay multivibrator has become stable.

p. Wide Gate Delay Multivibrator. The function of the wide gate delay multivibrator is to delay the brightening of the 32,000-yard sweep until the transmitter trigger starts the main pulse.

q. Wide Gate Width Multivibrator. The wide gate width multivibrator is triggered by the lagging edge of the wide gate delay multivibrator output, and produces a pulse which lasts for 32,000 yards of range. This pulse is used to brighten the coarse range scope and make all the received signals within the 32,000-yard range visible.



TL 47126

Figure 92. Crystal oscillator, simplified schematic diagram.

90. CRYSTAL OSCILLATOR.

a. The crystal oscillator consists of pentode tube V601 and the frequency control crystals Y601 and Y602. It is a tri-tet oscillator; the cathode, control grid, and screen grid forming the triode oscillator section, the cathode, and control grid, suppressor grid, and plate forming the elements of a tetrode buffer or amplifier stage. A simplified schematic of this stage is shown in figure 92(A).

b. The control of frequency by means of a crystal depends upon the piezo-electric effect. If a voltage is applied to a crystal, the crystal will expand or contract, and conversely, if a crystal is deformed, it will generate a voltage. If the potential applied to the crystal is alternating, the crystal is set into vibration, the amplitude being greatest at the mechanical resonance frequency of the crystal. Thus a crystal is equivalent to an electrical resonant circuit having a tuned frequency dependent upon the physical properties of the crystal. The value of a crystal in controlling frequency lies in the extreme sharpness of its resonance curve. The crystals used in the SCR-784 range unit are very stable, holding the frequency of oscillation constant to within ±4 cycles per second for temperature variations up to 100 degrees Centigrade. This amounts to a range error of less than 2 yards at 32,000 yards range, and less at lower ranges.

c. At the frequency of operation of the oscillator, the crystal and coil L601 both present an inductive reactance. Considering only the oscillator section of the tube, and representing the control-grid to screen-grid capacitance as capacitor C, the equivalent circuit of the oscillator becomes as shown in figure 92(B). The impedance of capacitor C603 is so small that it can be considered as a direct connection. Resistor R601 (the d-c grid return) and R602 with C602 (cathode bias circuit) are omitted from the equivalent circuit for they only set the operating point of the oscillator. The screen grid of V601 is shown as a plate, for it operates as a plate in the oscillator section of the tube. It can be seen from the equivalent circuit of the oscillator that any oscillations in the resonant circuit made up of C, Y601, and L601 will be sustained by the feedback action of the triode in a manner similar to the operation of a

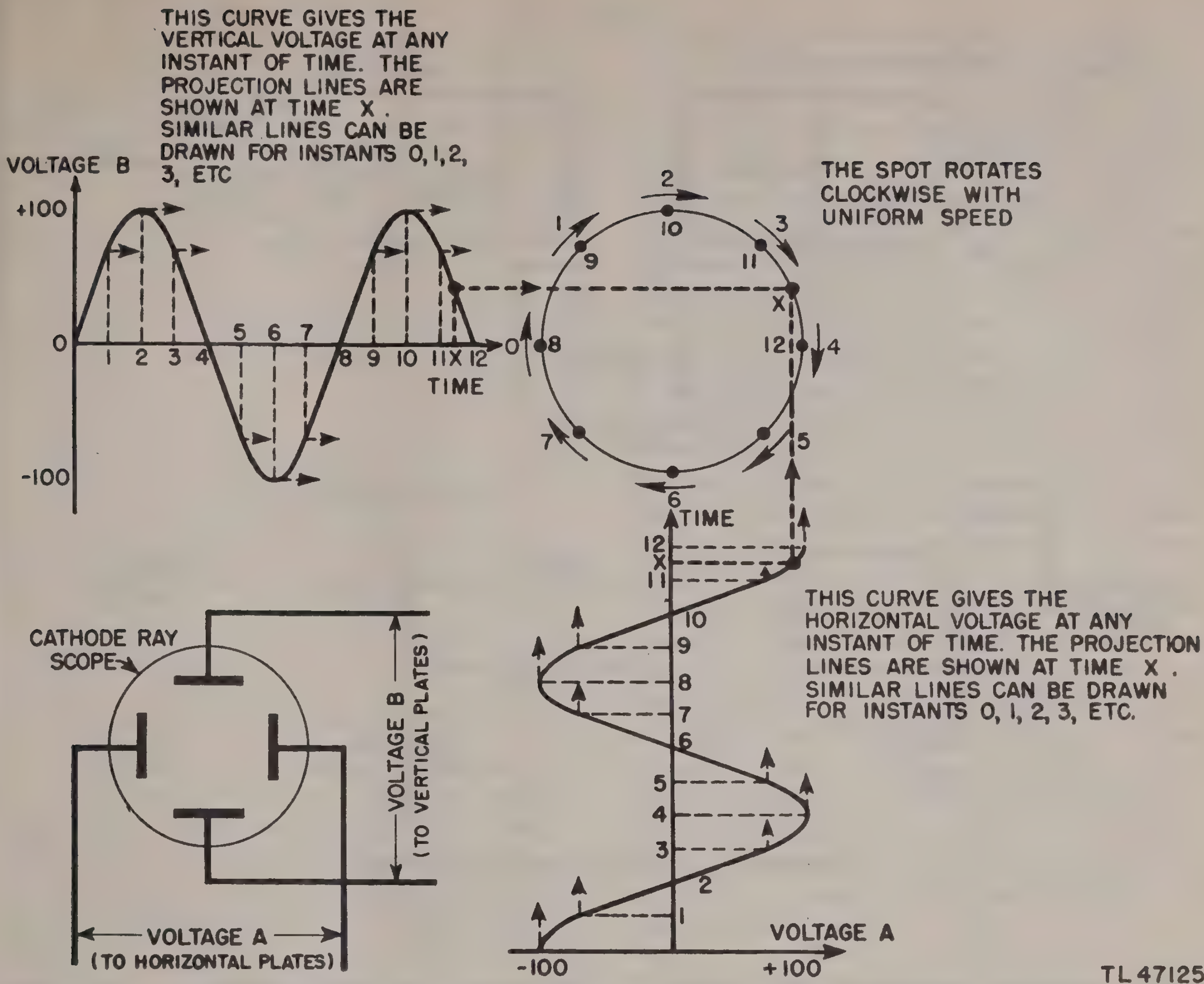


Figure 93. Formation of circular sweep.

Hartley oscillator. The amplitude of the oscillations is controlled by the 2,000-YD SWEEP DIAMETER control which changes the oscillator plate (the screen grid) voltage.

d. The load is electron coupled to the oscillator circuit. The control grid and screen grid in the oscillator circuit produce a sine wave modulation of the electron flow to the plate and its load. The suppressor grid isolates the plate from the oscillator section of the tube, thus making the oscillations independent of variations in the load.

91. 2,000-YARD SWEEP TRANSFORMER.

a. Circular Sweep. A circular sweep is produced on the range scopes by applying two voltages 90 degrees out-of-phase to the horizontal and vertical deflection plates of a cathode-ray tube. The two voltage waves obtained from the sweep transformer are shown in figure 93. Voltage B leads voltage A by 90 degrees; it goes through zero one-quarter cycle before voltage A does, and similarly, voltage B goes through a maximum one-quarter cycle before voltage A does. The position of the spot at any instant depends upon the value of the two voltages at that instant. The horizontal deflection is proportional to voltage A and the vertical deflection is proportional to voltage B. The construction in figure 93 shows how to plot the position of the spot on the face of the scope at any instant. From this plot it can be seen that the spot travels around a circle at uniform speed, producing a linear circular sweep.

b. Sweep Transformer. The two voltages A and B are made 90 degrees out-of-phase by using the tuned sweep transformer T601 (fig. 94(A)). The primary winding L_1 and the secondary winding L_2 are loosely coupled. Winding A is

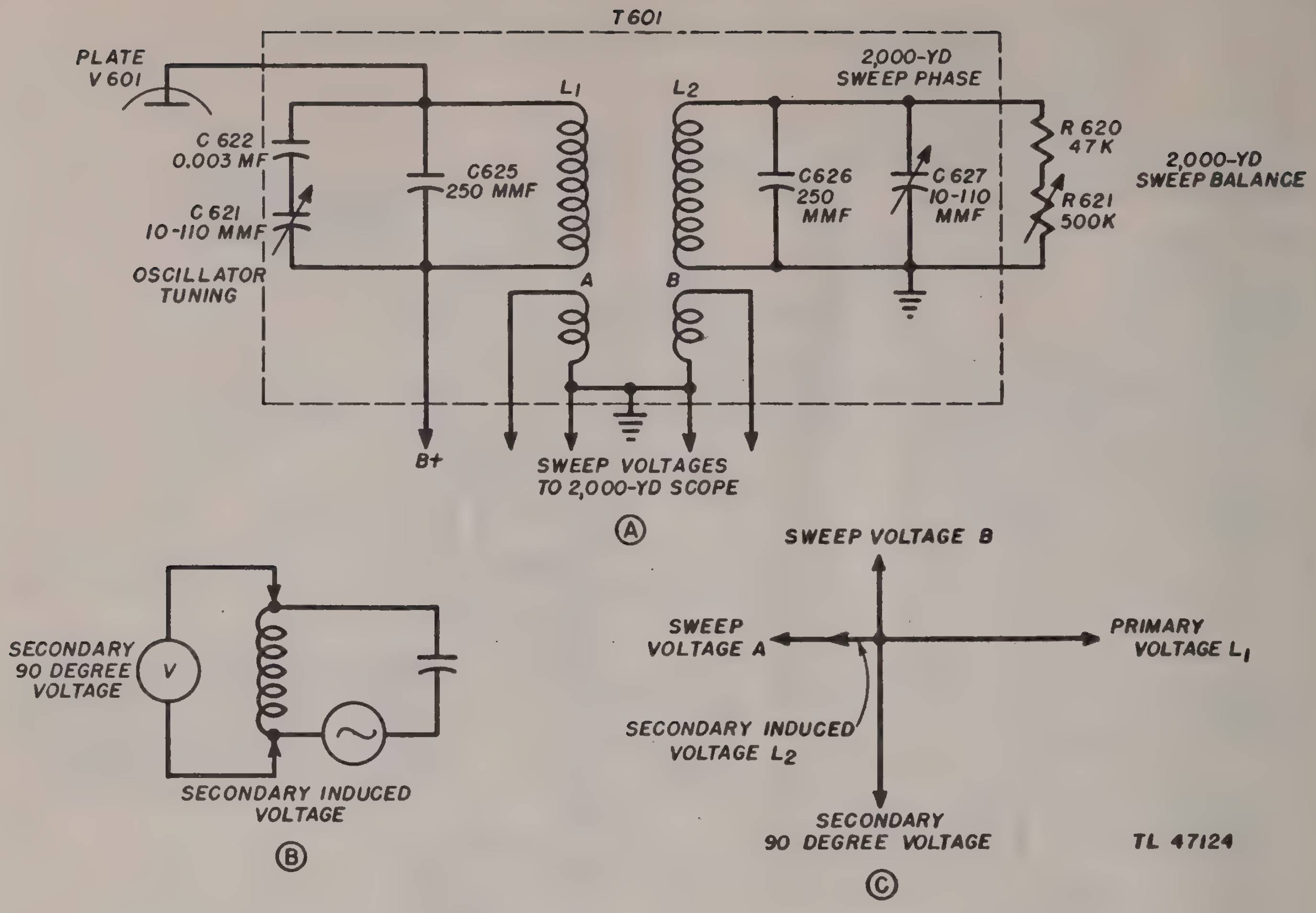


Figure 94. 2,000-yard sweep transformer.

tightly coupled to the primary, and winding B is tightly coupled to the secondary. The phase relationships in the transformer are summarized below and are shown vectorially in figure 94(C).

(*1*) The voltage induced in A is 180 degrees out-of-phase with the voltage applied to primary L_1 because of transformer action.

(*2*) The voltage induced in L_2 is also 180 degrees out-of-phase with the primary voltage for the same reason, but this small induced voltage (small because L_1 is loosely coupled to L_2) causes a large current to flow in L_2 which appears as a series resonant circuit to this induced voltage (fig. 94(B)). This current is in phase with the induced voltage, for at resonance, the tuned circuit appears as a pure resistance. This in-phase current flowing through inductance L_2 causes a very large voltage (large because of the Q of the tuned circuit) to appear across inductance L_2. Since the voltage across an inductance leads the current by 90°, this large voltage is 90° out-of-phase with the current which is 180° out-of-phase with the voltage across L_1; thus this large voltage is 90° out-of-phase with the voltage across L_1. Thus there are two voltages in winding L_2, one 180 degrees out-of-phase with the primary voltage which causes a larger one 90 degree out-of-phase with the primary voltage. The 180-degree voltage can be neglected, for it is small compared with the 90-degree voltage (the primary to secondary coupling is small, and the Q of the secondary is large). This large 90-degree voltage induces a voltage in B that is 180 degrees out-of-phase with the 90-degree voltage and thus 90 degrees out-of-phase with the primary voltage and the voltage induced in winding A.

c. Sweep Adjustments.

(*1*) *2,000-yard Sweep Diameter.* This control (R698 in fig. 92) varies the screen grid voltage (the plate voltage of the oscillator section of the tri-tet oscillator) and therefore affects the amplitude of the oscillator output. Since it varies the amplitudes of both the voltages induced in windings A and B proportionally, it affects only the diameter of the sweep trace and not the shape.

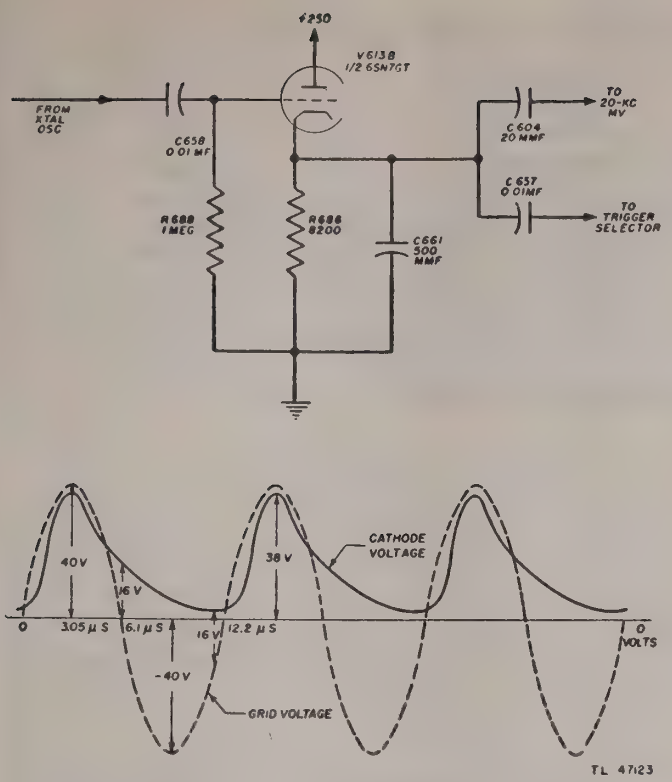


Figure 95. Trigger generator.

(2) *Oscillator Tuning.* This control does not change the oscillator frequency, it simply tunes the sweep transformer primary to resonance. It affects both voltages A and B and should be set to make both these voltages maximum, that is, the sweep diameter maximum.

(3) *2,000-yard Sweep Phase.* This control is used to adjust the tuning of the secondary circuit. It is labeled phase because changing the tuning of the secondary varies the phase of the secondary current and hence the phase of voltage B. It is adjusted so that a circular sweep is obtained.

(4) *2,000-yard Sweep Balance.* This control adds resistance to the secondary circuit of the sweep transformer, lowering the Q of that circuit and thus lowering the voltage induced in winding B without changing the voltage induced in A. This control should be set so that the voltage induced in B is the same value as the voltage induced in A, that is, until a circular sweep is obtained. This control and the 2,000-yard sweep phase control affect the circularity of the sweep trace, and both must be alternately adjusted to obtain a circular trace.

92. TRIGGER GENERATOR.

Tube V613B is employed as the trigger generator. The function of this stage is to generate triggers from the sine wave oscillator output. This circuit is shown in figure 95. When the grid is driven positive by the incoming signal, the tube conducts and causes a positive voltage to be developed across cathode resistor R686. This voltage increase, lasting for approximately 3 microseconds, charges capacitor C661, the cathode bypass, to 38 volts. The time constant of the circuit formed by C661 and R686 is 4.1 microseconds. When the signal on the grid starts to swing in the negative direction the voltage at the cathode tends to decrease. The capacitor discharges at an exponential rate which is much slower than the drop of the input signal, and at 6.1 microseconds when the signal is at zero, the cathode still has a bias of approximately +16 volts. Tube V613B is now cut off and remains cut off until the signal passes its maximum negative value (-40 volts) and returns to approximately -16 volts. At this time, the cathode voltage is about zero, and the tube begins to conduct. Capacitor C661 starts to recharge but there will be no appreciable change in cathode voltage until the grid signal reaches a positive value. At this point capacitor C661 rapidly charges to the initial value. The output is a series of positive peaked waves varying above ground level. This trigger voltage is fed to the 20-kc multivibrator and to the trigger selector stage.

93. 20-KC MULTIVIBRATOR.

The function of the 20-kc multivibrator (fig. 96) is to reduce the 81.95-kc crystal control frequency to ¼ of its value, that is, to 20.49 kc. This is accomplished by using a multivibrator having a free running frequency slightly lower than 20.49 kc and feeding the 81.95-kc trigger pips so as to lock the multivibrator at exactly 20.49 kc by every fourth trigger pip.

a. Assume at the start that tube V602B is cut off. The grid side of parallel capacitors C606 and C607 is negative with respect to ground, but the capacitors are discharging to bring the grid voltage toward ground. The grid side of capacitor C605 is slightly above cathode potential. The voltage at plate 2 of V602 is minimum while that of plate 5 is maximum.

b. When the grid of tube V602B approaches zero, V602B conducts and the voltage at plate 5 drops. This drop is applied to grid 1 of V602 through coupling capacitor C605. This reduces the current through tube V602A and the voltage at plate 2 rises. This voltage rise is applied to grid 4 by capacitors C606 and C607. The grid

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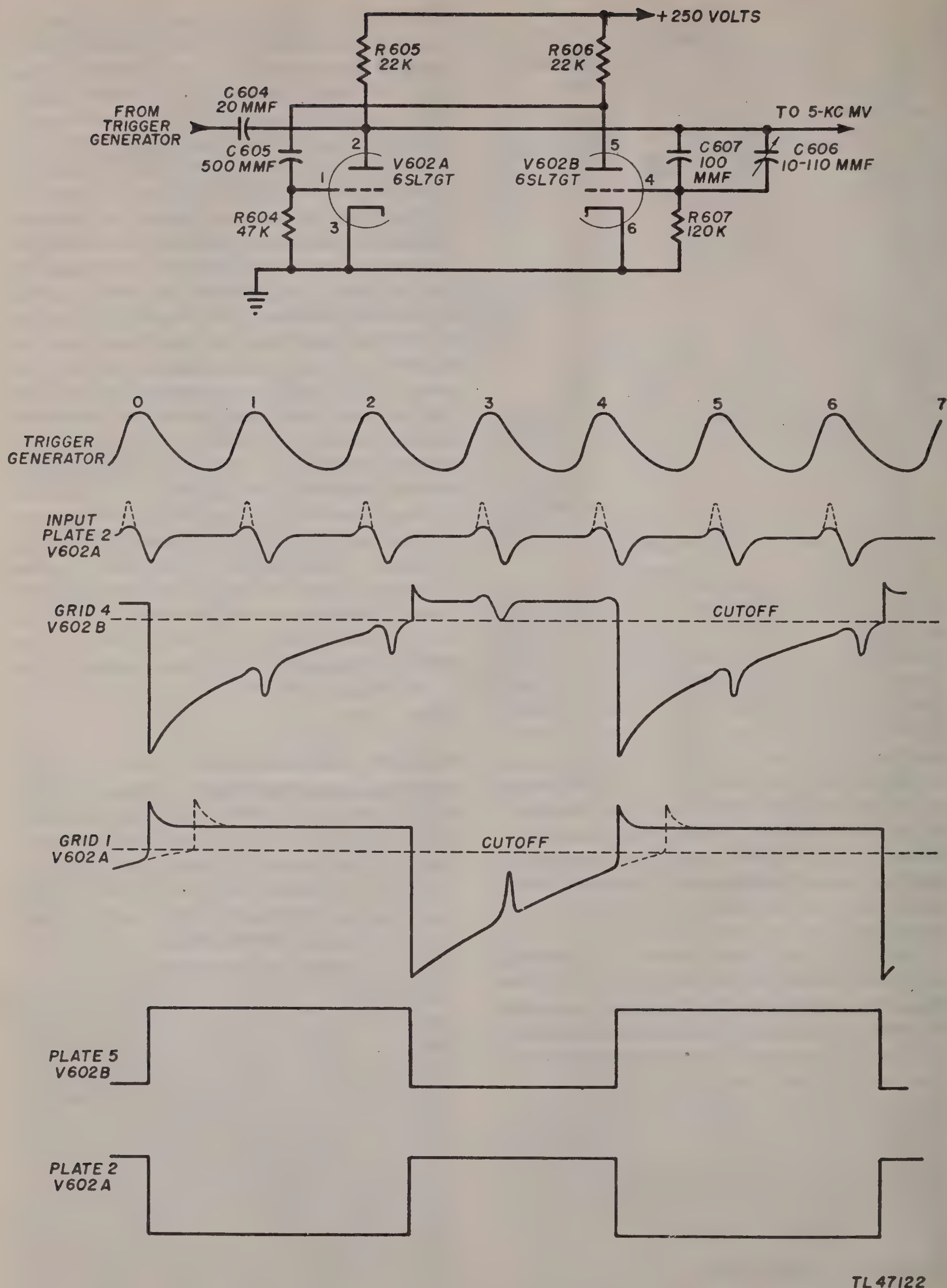

Figure 96. 20-kc multivibrator.

side of capacitors C606 and C607 assume a positive potential and the voltage at plate 5 is further reduced. This additional drop drives grid 1 of V602 well beyond cut-off and capacitor C605 is left with a charge that is negative with respect to ground. If there were no synchronizing pulses, grid 1 of tube V602 would approach ground potential in a time determined by the time constants of the discharge circuit, and tube V602A would conduct causing tube V602B to be cut off again for a new cycle of operation to start.

c. The synchronizing trigger output of the trigger generator is differentiated in the input circuit and the resulting positive and negative pulses are applied to the multivibrator through grid 4 of tube V602. The positive peaks are rounded off because when tube V602A is conducting they cannot increase the plate current and when V602B is conducting they have no effect on an already positive grid. The negative pulses applied to grid 4 of V602B are amplified when V602B is conducting and applied to grid 1 of V602A as large positive pulses. When grid 1 of V602 is operating below cut-off, the positive pulses applied to the grid drive the grid voltage toward the cut-off point and every fourth trigger causes the stage to conduct. Normally grid 1 will tend to drive V602A into conduction as indicated by the dotted line (fig. 96) but the trigger drives the tube into conduction before this happens and locks the multivibrator to one fourth the frequency of the crystal oscillator. Tube V602B conducts when the normal discharge of the capacitor brings grid 4 above cut-off. The 20-KC MV control C606 changes the time constant of the grid discharge circuit of V602B. When properly adjusted, the natural frequency of the multivibrator should be a little lower than the frequency to which the multivibrator is going to be locked.

94. 5-KC MULTIVIBRATOR.

a. The output of the 20-kc multivibrator, a negative square wave from the plate of tube V602A, is coupled to the grid of V603B through coupling capacitor C608. This small capacitor differentiates the square wave, producing sharp negative and positive pips. The 5-kc multivibrator is of the free-running type similar to the 20-kc multivibrator, but having a free-running frequency of slightly less than 5.12 kc. The operation of this multivibrator (see the waveforms in figure 97) is similar to that of the 20-kc

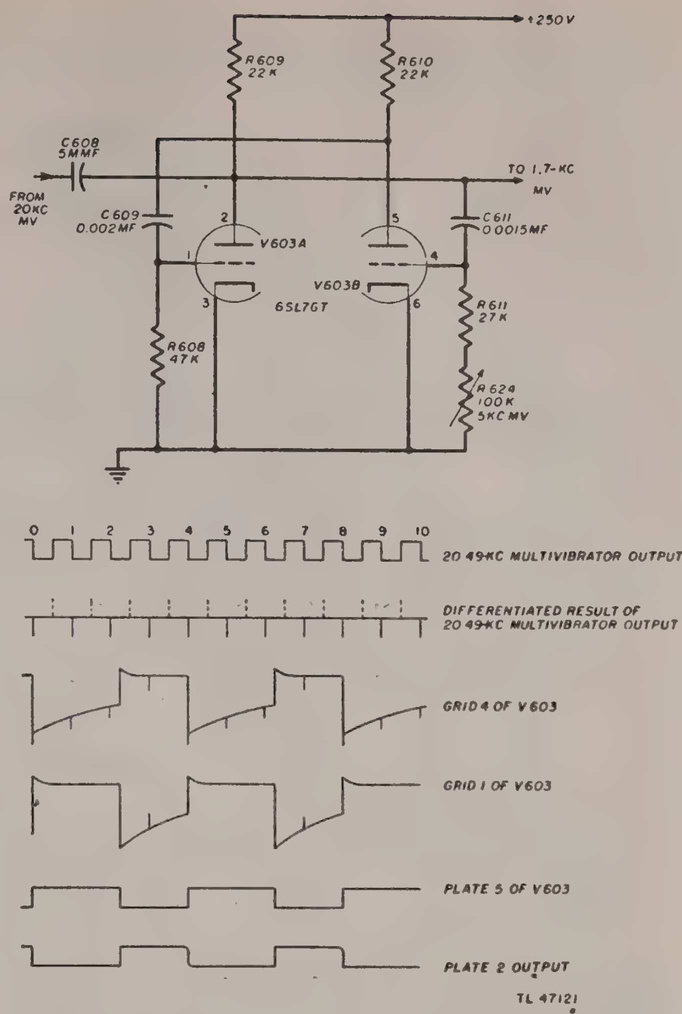

Figure 97. 5-kc multivibrator.

multivibrator, its output being a negative rectangular wave of ¼ the recurrence frequency of the input triggers. This reduces the oscillator frequency to ¼ x ¼ x 81.95 kc or to 5.12 kc.

b. The 5-KC MV control varies the time constant of the discharge circuit of one grid coupling capacitor. When properly adjusted, the multivibrator is synchronized to 1/16 the oscillator frequency. Resistors are used in this and the rest of the lower frequency multivibrators to control the frequency. At low frequencies, a trimmer capacitor as used in the 20-kc multivibrator would have to cover too large a range if fixed resistors were used.

95. 1.7-KC MULTIVIBRATOR.

a. The 1.7-kc multivibrator, V604 (fig. 141) is similar to the 20-kc and 5-kc multivibrators. The negative square wave output from the 5-kc multivibrator is differentiated by the 5 mmf capacitor C612 and the trigger pips formed are fed to the grid of V604B.

b. When the 1.7-KC MV control R616 is properly adjusted, every third negative trigger

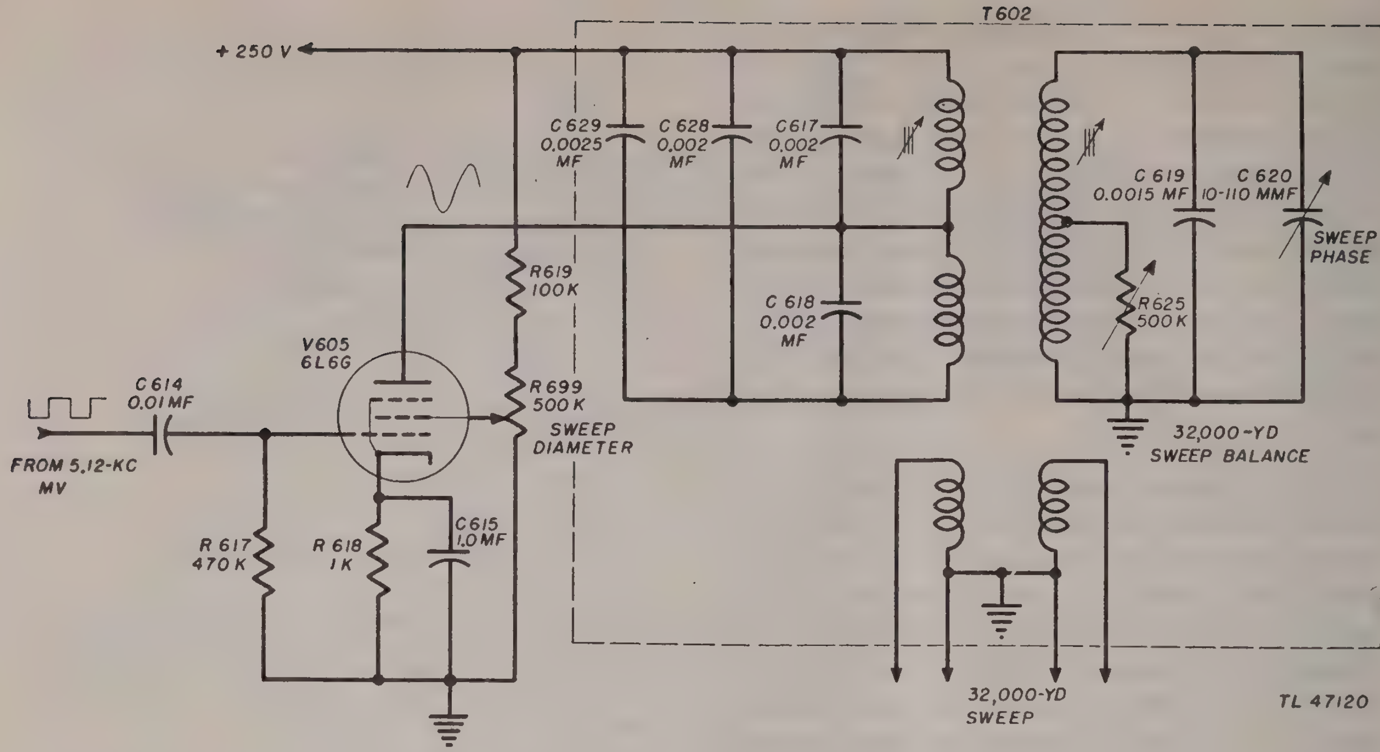

Figure 98. 5-kc amplifier.

pip triggers the multivibrator. The frequency of this multivibrator is exactly ¼ x ¼ x ⅓, 1/48 of the 81.95-kc crystal frequency or 1.7 kc.

96. 5-KC AMPLIFIER AND 32,000-YARD SWEEP TRANSFORMER.

a. The output of the 5-kc multivibrator is amplified in the 5-kc amplifier (fig. 98). This amplifier is tuned to the fundamental frequency of the square wave input; so although the grid signal is a 5.12-kc square wave, the plate voltage is a 5.12-kc sine wave.

b. The 32,000-yard sweep transformer functions the same as the 2,000-yard sweep transformer discussed in paragraph 91. Because of the lower frequency involved, the 32,000-yard sweep transformer is made with a powdered iron core. Tuning of this transformer is accomplished by changing the position of the iron core in the coils. The primary impedance of this transformer is matched to the output impedance of the amplifier tube by tapping the coil and connecting the plate to this tap rather than to connect the plate across the whole coil. The 32,000-yard balance control resistor is not connected across the whole secondary as was the 2,000-yard balance control. By connecting the control across a low impedance part of the secondary winding, a 500K-ohm control can be used rather than one of several megohms which would be required if the tap were not used.

c. The controls provided for adjusting the 32,000-yard sweep are similar in all respects to the corresponding controls for the 2,000-yard sweep. There is no panel control in the 32,000-yard sweep that corresponds to the 2,000-yard OSCILLATOR TUNING control. Instead, movable iron plugs are adjusted for tuning the 32,000-yard sweep transformer.

97. 1.7-KC CLIPPER.

The square wave output from the 1.7-kc multivibrator is amplified and squared by the 1.7-kc clipper in order to give steeper sides to the square wave pulse for better triggers to the delay multivibrators. This stage is an overdriven amplifier, normally conducting in the absence of the square wave input. The cathode resistor and capacitors limit the tube current to a safe value in the absence of the input. The waveforms in figure 99 show the operation of this stage.

98. TRIGGER GATE DELAY MULTIVIBRATOR.

a. The delay multivibrator V611 differs from the type already described in the preceding paragraphs. The usual R-C coupling network between the plate of one section and the grid of the other section is omitted. Instead the two cathodes are connected to ground through a common cathode resistor R675. This type of multivibrator is called a cathode coupled multi-

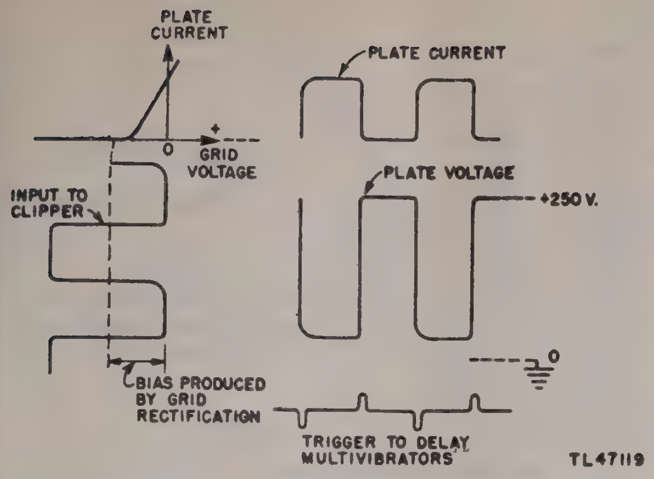

Figure 99. Clipper circuit operation.

vibrator. A simplified schematic is shown in figure 100. Between triggers the second section, tube V611B, is conducting heavily and the first section, V611A, is at cut-off. The grid of the first section is given a positive bias from the voltage divider network R672, R673, and R674. The grid bias can be varied from about +10 to +27 volts depending on the position of the TRIGGER DELAY potentiometer R673. The grid of the second section is tied to B+ through the 3.3 megohm resistor R678. This resistor is made large to limit the grid current flow when the section conducts, and provides a high resistance discharge path for the R-C network when the section is cut-off. With the second section conducting heavily the current flow through the common cathode resistor R675 develops a positive bias on the cathode of approximately 40 volts.

b. With a setting of 12 volts on the grid of tube V611A by the TRIGGER DELAY control, the net bias is 28 volts, holding the first section well below cut-off; grid capacitor C653 is charged to 210 volts, the difference between the plate supply and the potential at the grid. The square wave output from the 1.7-kc multivibrator is differentiated in the short time-constant circuit formed by capacitor C651 and resistors R671, R672, and R673. Sharp positive and negative pips are developed, only the positive pips serving to trigger the circuit. The trigger applied to grid 1 of tube V611 overcomes the bias on the non-conducting section, and the tube conducts. Immediately the plate voltage drops; this drop is coupled through C653 to the second section driving it beyond cut-off. The amount of current flow through the cathode resistor is less with the first section conducting than when the second section is conducting. Thus the cathode voltage drops to a lower level, see figure 101, but section V611B is still held beyond cut-off. Capacitor C653 begins to discharge through resistor R678, and as a result the voltage at the grid of tube V611B rises at a rate determined by the time constant of R678 and C653. When the negative voltage at the grid of V611B decreases to the value where the section can conduct (about 16 volts below the cathode) the voltage across the common cathode increases until a point is reached where tube V611A is cut off. The circuit is restored to its original state and remains in this condition until another positive pip is applied to the grid of V611A.

c. The width of the pulse produced depends upon the voltage applied to the grid of V611A by the TRIGGER DELAY control as shown in figure 101. The effect of increasing the delay voltage is to increase the limits over which the discharge of C653 takes place before tube V611B conducts and V611A is cut off. Raising the grid voltage reduces the bias on V611A when it conducts. This causes the plate voltage to

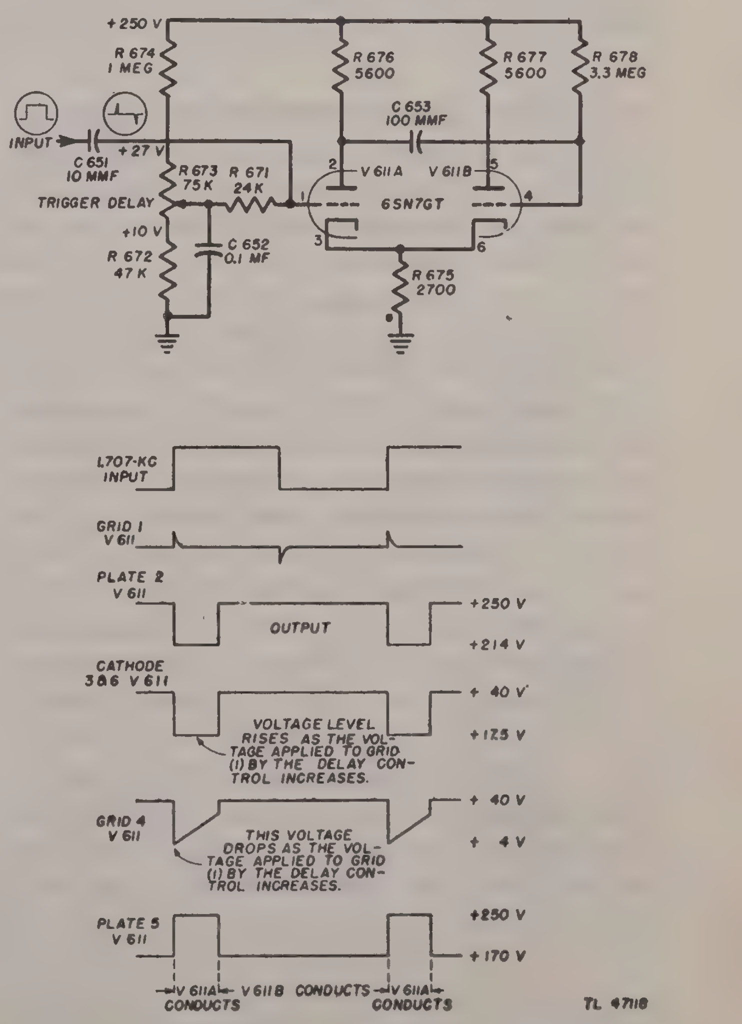

Figure 100. Trigger gate delay multivibrator.

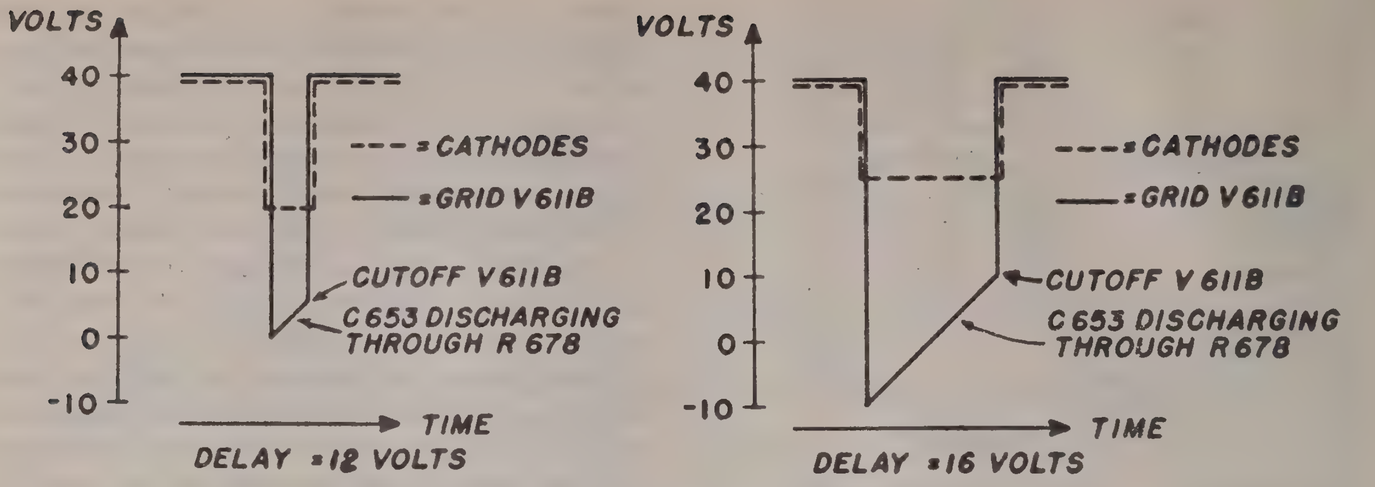

Figure 101. Delay multivibrator operation. TL 47117

drop further and the cathode potential to drop less. The drop in plate voltage is coupled to the grid of V611B and hence the grid is driven more negative. This increases the length of time it takes for the grid to bring V611B into conduction and hence the delay time. Since the time required for capacitor C653 to discharge is proportional to the amount of voltage it must lose, it is evident that the pulse width can be controlled by the d-c voltage which the TRIGGER DELAY control applies to the grid of tube V611A.

99. TRIGGER GATE WIDTH MULTIVIBRATOR.

The trigger gate width multivibrator, V612, (fig. 141) functions in a manner similar to the trigger delay multivibrator, with the exception that no provision is made to vary the width of the output pulse. The square wave output fed to the grid of this circuit is differentiated by the short time constant circuit formed by capacitor C654 and resistor R679. Simplified waveforms are shown in figure 102. The positive trigger pip is developed from the variable edge of the input square wave, thus the time of triggering the circuit is directly dependent on the width of the input. The action of this circuit is similar to that described in detail for the trigger gate delay multivibrator. The length of time that V612B remains cut off is approximately 6 microseconds. This interval is not adjustable but it may vary from 5 to 9 microseconds because of variations in the tube and associated components. So long as the width does not exceed 12 microseconds, there is no possibility of two closely spaced transmitter trigger pips being formed for the pips are 12.2 microseconds apart. The output is taken from the plate of V612B and applied to the trigger gate cathode follower.

100. TRIGGER GATE CATHODE FOLLOWER.

The square wave output from the trigger gate delay multivibrator is fed to the cathode follower circuit V613A (fig. 103). This is a conventional circuit and is used to minimize the capacitance shunted across the plate of V612B and provide a low impedance output to the screen grid of V614. The output taken from the cathode is positive and similar to the input pulse.

101. TRIGGER SELECTOR.

a. The trigger selector stage, V614 (fig. 103) controls the timing of the trigger input pulse fed to the transmitter, automatic range tracking unit, and PPI. The tube is normally at cut-off, the control grid and screen grid biased negatively. The two inputs from the trigger generator and the trigger gate cathode follower fed to the tube, causing conduction, are applied to the control and screen grid respectively. With the type of bias used, the tube cannot conduct

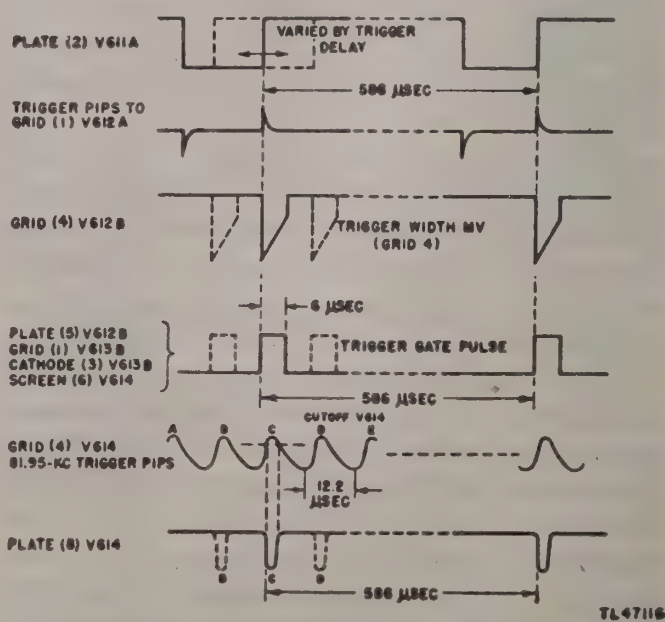

Figure 102. Trigger circuit waveforms.

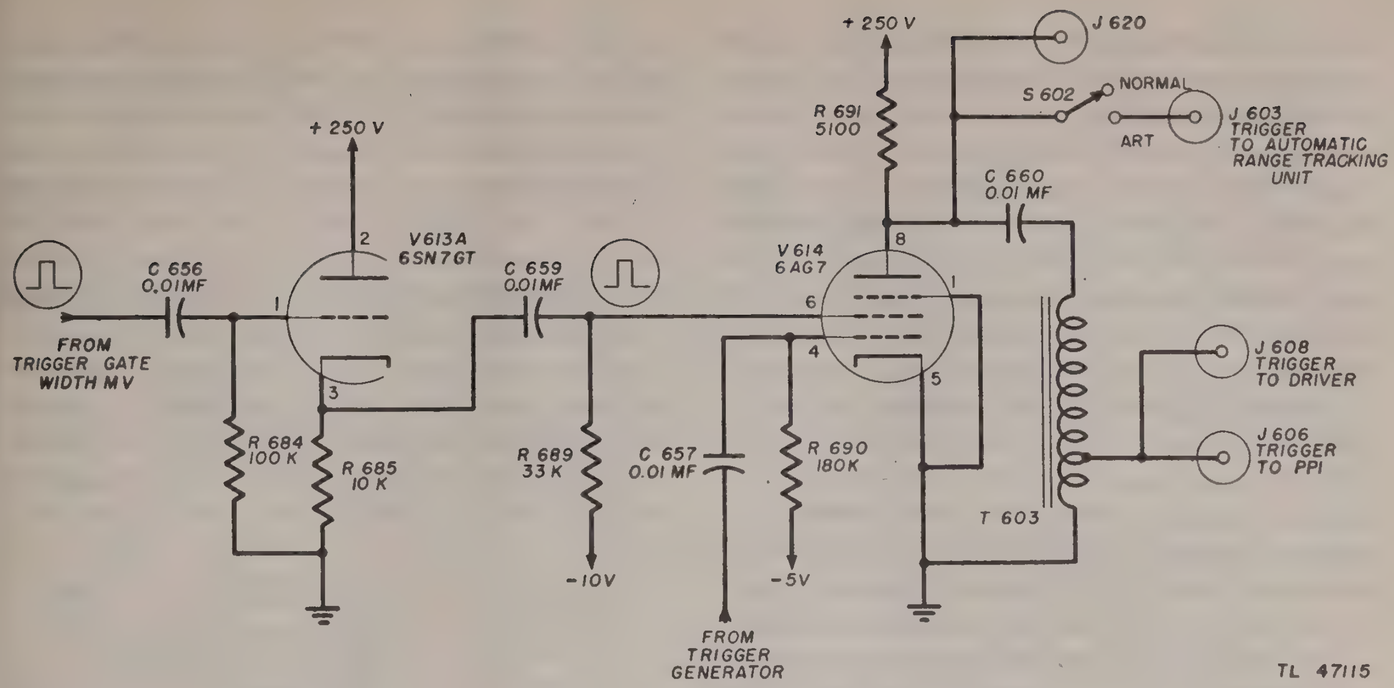

Figure 103. Trigger gate cathode follower and trigger selector.

unless both inputs are applied to the tube at the same time. The tube is sometimes called a "coincidence" tube because of this action.

b. The adjustment of the TRIGGER DELAY control selects one of the three possible trigger pips shown in figure 102. The first 81.95-kc pip A corresponds to that which triggers the 20-kc multivibrator and in turn the various delay circuits. The trigger gate delay should be adjusted so as to select pip C, which is the second of the three possible pips which can be selected. As a result of this timing sequence, the transmitter is not keyed until approximately 24 microseconds after the narrow gate delay multivibrator has been triggered. This allows time for the narrow gate multivibrator to be operating linearly. At delays shorter than 10 or 12 microseconds the narrow gate delay circuit operation is non-linear. Thus it is not desirable to key the transmitter with pips A or B. When the tube does conduct, a negative ouput trigger pulse is developed across plate resistor R691. The step-down transformer T603 provides a low output impedance match for the cables attached to jacks J606 and J608. The trigger to the automatic range tracking unit is taken from the plate of the stage where a larger voltage trigger is obtained.

102. WIDE GATE DELAY MULTIVIBRATOR.

a. The wide gate delay multivibrator functions in the same way as the trigger gate delay multivibrator described in paragraph 98. Some of the circuit components have slightly different values but their effect is only to change the R-C time constant circuit and thus the recovery time of the stage to the initial operating level. The delay is varied by means of the WIDE GATE DELAY control R656 (fig. 141) which is located on the front panel.

b. The purpose of this delay circuit is to trigger the wide gate width multivibrator at the exact instant that the transmitter is triggered. This assures that the beginning of the trace on the 32,000-yard scope is brightened at the moment the transmitter fires (fig. 91).

103. WIDE GATE WIDTH MULTIVIBRATOR.

a. This circuit (fig. 104) is that of a conventional "one kick multivibrator", so called because the circuit remains inoperative until the application of a trigger pulse. In the absence of a trigger, section V610A is conducting heavily as the grid is tied to the voltage divider network R661 and R662 between B+ and ground at a point about 3.7 volts positive. The second section, V610B, is cut off, the grid being biased at a negative 10 volts.

b. The positive square wave input from the wide gate delay multivibrator is differentiated by the R-C network capacitor C646 and resistor R663. A positive and a negative pip is developed, the positive pip from the leading edge, and the negative from the trailing or variable edge, see figure 104. The positive pip has no effect on the stage as the tube is already conducting,

but the negative pip when applied to the grid is amplified and coupled to the grid of the second section as a positive pulse, causing that section to conduct. The following actions then take place. The voltage at the plate of tube V610B decreases, coupling a negative voltage to the grid of V610A. The voltage at the plate of tube V610A increases, coupling a positive voltage back to grid 4 of V610B, and the cumulative action drives V610A well beyond cut-off. As shown in figure 104, the negative charge on C647 now starts to leak off and the grid of V610A starts rising at a rate determined by the time constant of R663 and C647. When the voltage has decreased sufficiently so that V610A conducts, plate 2 voltage decreases, the voltage at the grid of V610B decreases, the plate voltage of V610B increases, and V610A conducts heavily with V610B left in a cut-off condition. The multivibrator remains inactive until the arrival of the next negative pip.

c. The width of the pulse developed at the plate of V610A depends on the length of time the section is held at cut-off. The WIDE GATE WIDTH control, R663, varies the time constant in the grid circuit of V610A, and hence controls the width of the pulse. The dotted lines in the grid and plate waveforms of figure 104 shows the effect of decreasing the resistance of the WIDE GATE WIDTH control. With proper adjustment, only the first 32,000 yards of the sweep on the coarse range scope are brightened. If the width of the pulse is too small, the circle is incomplete. If the width is too great, the trace is illuminated for more than 32,000 yards, and it is difficult to select the proper target echo. The pulse is taken from the junction of the plate load resistors to reduce the voltage applied to the scope and reduce loading effects on the plate circuit by the capacitance of the connecting cables and scope circuits.

104. NARROW GATE DELAY MULTIVIBRATOR.

a. The narrow gate delay multivibrator, tube V607, is a conventional cathode coupled multivibrator similar to the trigger and wide gate delay multivibrators. However, there is one major difference in that this circuit is automatically instead of manually controlled as in the other circuits. A simplified schematic diagram is shown in figure 105. The narrow gate range potentiometer R901 mounted in the range indicator unit forms part of the grid voltage divider circuit of V607A. The potentiometer slider is driven by the range gearing, the gear ratio being such that the entire range of the potentiometer from **b** to **c** is covered as the range hairlines are rotated from 0 to 32,000 yards. The output voltage from the slider at any instant thus depends on the range, and in turn controls the position of the lagging edge of the output pulse from the multivibrator. This lagging edge determines the position of the narrow gate pulse which brightens a sector of the 2,000-yard scope. Potentiometer R636, NARROW GATE CONTROL, is in parallel with the range potentiometer and serves as a

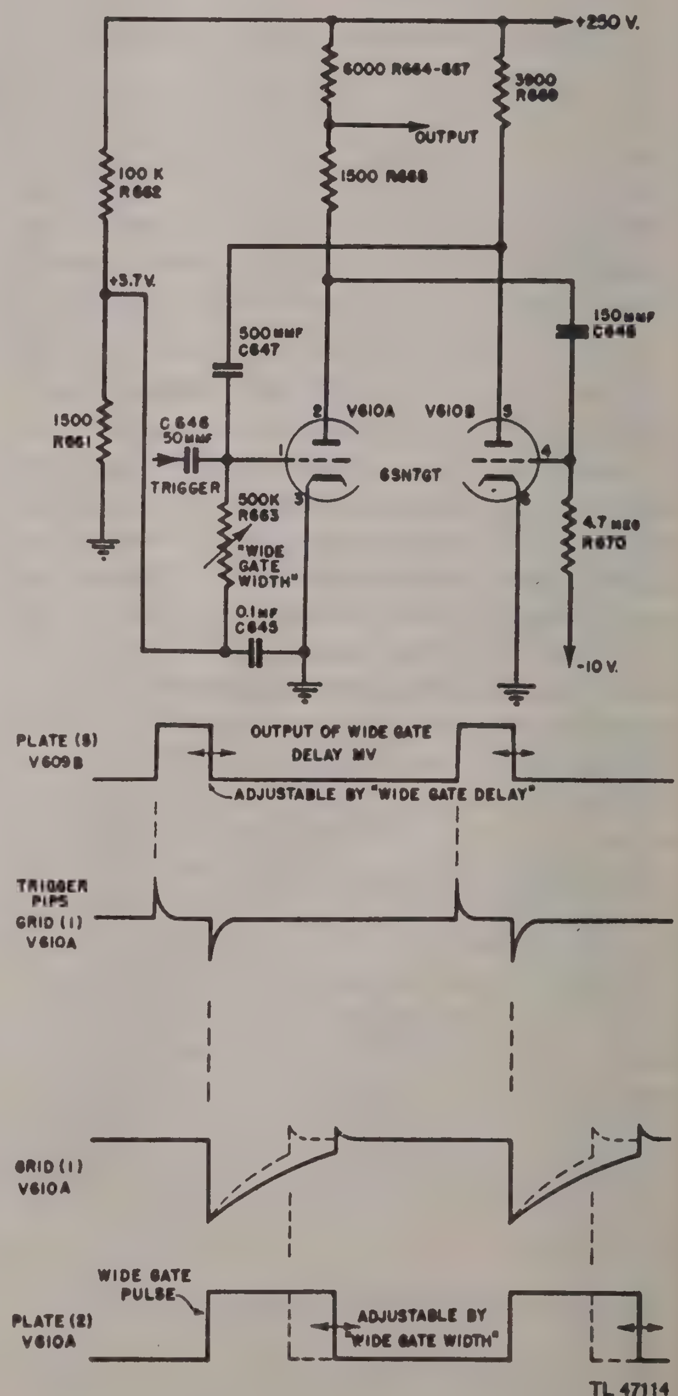

Figure 104. Wide gate width multivibrator.

fine adjustment at the higher values of range for controlling the total voltage drop across R901. The NARROW GATE DELAY control is in series with R901 and serves as an adjustment for lining up the narrow gate at the low values of range.

b. The effects of the NARROW GATE DELAY and NARROW GATE adjustments are shown in figure 106. Normally tube V607B is conducting heavily as its grid connects to +250 volts through R643, and V607A is held beyond cut-off by the potential developed by the common cathode resistor. At the arrival of the positive pip, the result of the differentiating of the 1.7-kc square wave, section V607A conducts and V607B is cut off. The amount of time

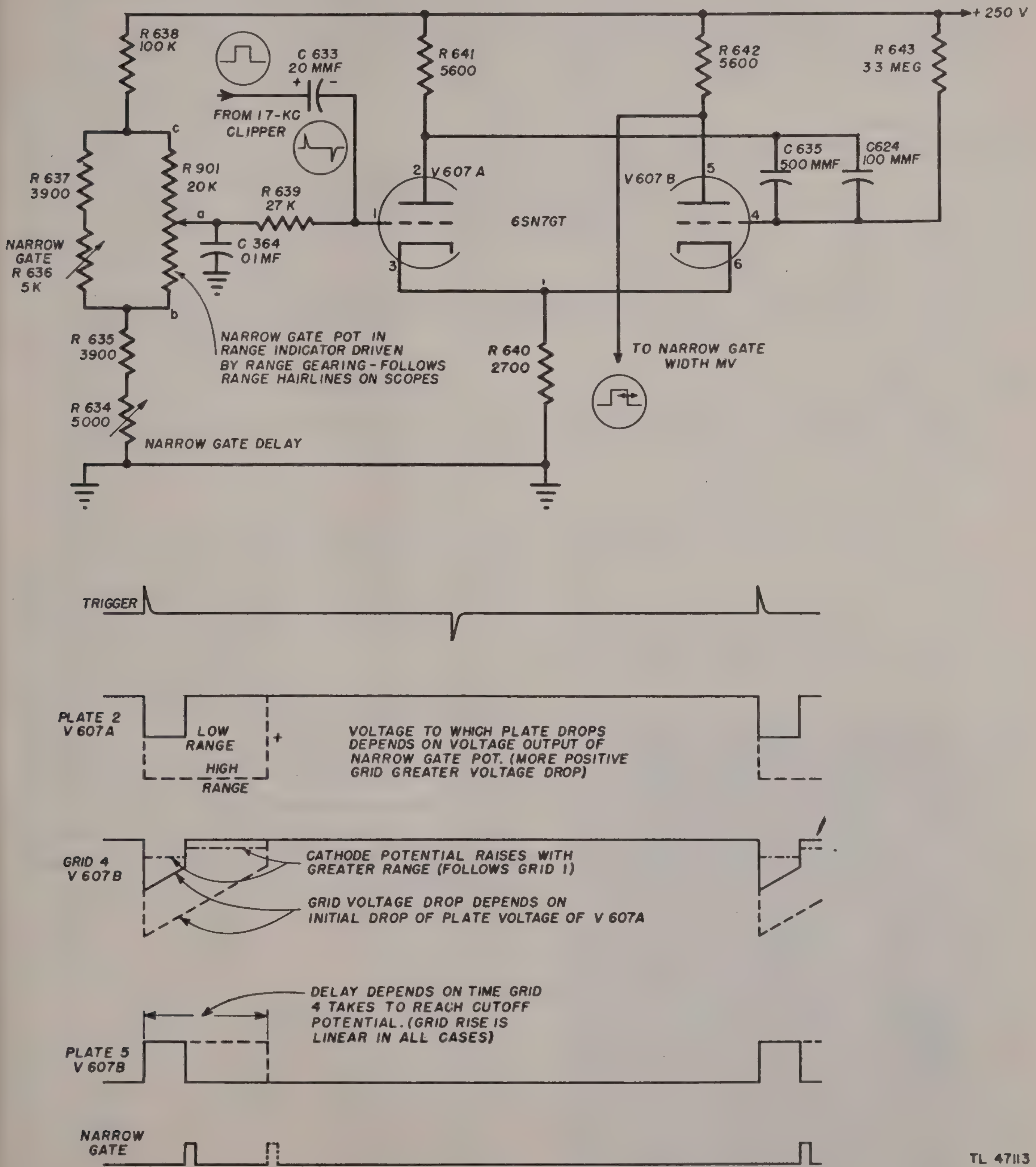

Figure 105. Narrow gate delay multivibrator.

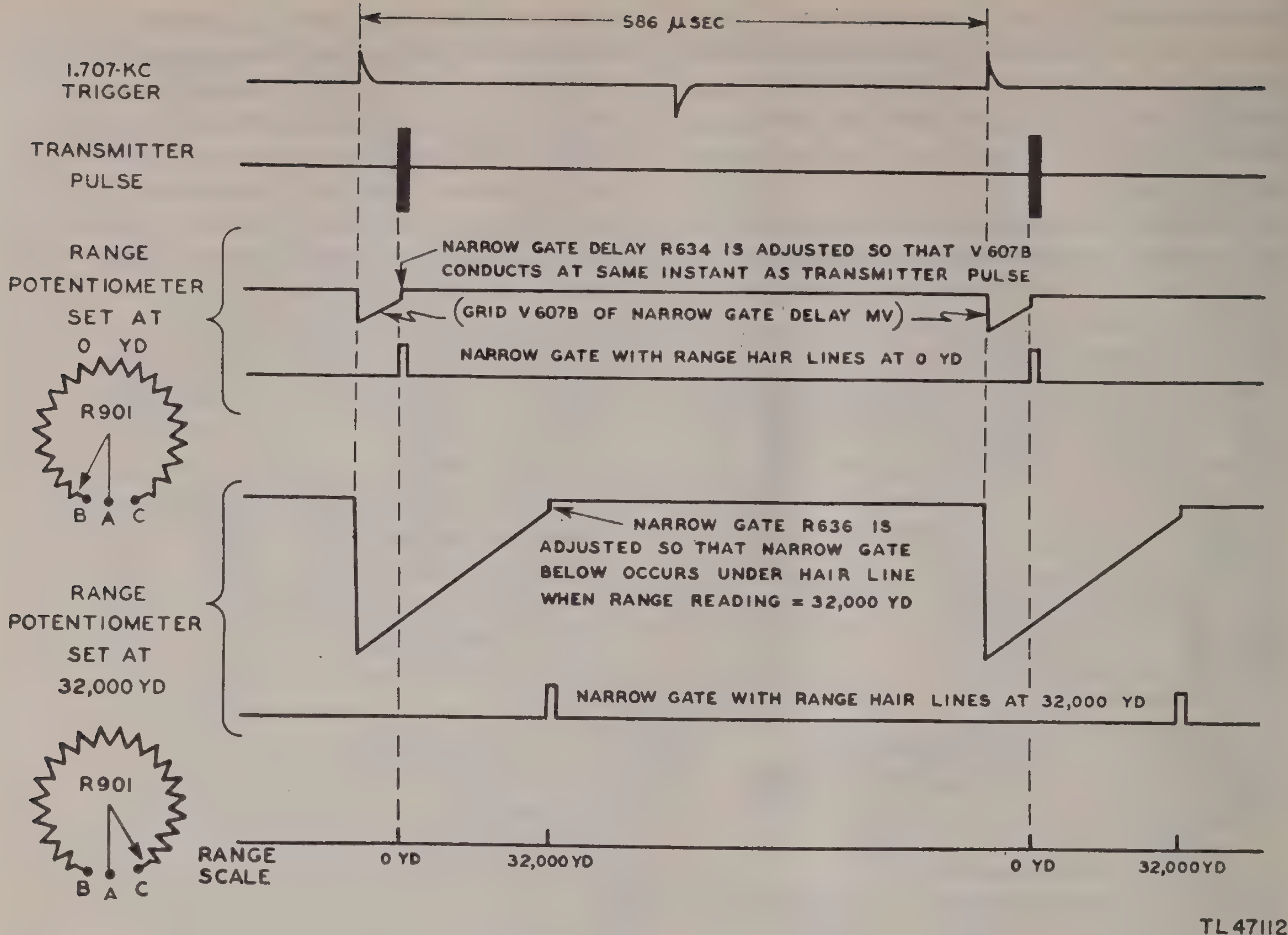

Figure 106. Effect of NARROW GATE DELAY and NARROW GATE adjustments.

that V607B remains cut off depends on the position of the slider on potentiometer R901, as in the trigger gate delay circuit. When the second section, V607B, again conducts, the lagging edge of the narrow gate delay pulse is formed. Since the common cathode voltage and the voltage drop on the grid of V607B is determined by the setting of R901, it follows that the width of the narrow gate delay pulse produced at the plate of V607B varies with the setting of this control.

105. NARROW GATE WIDTH MULTIVIBRATOR.

This stage, V608, functions exactly the same as the wide gate width multivibrator. The circuit constants are slightly different to provide the proper output widths. Two outputs are taken from this circuit (fig. 141), one from the plate of V608A, and one from the plate of V608B. The positive gate from V608A is coupled to the PPI through jack J604. The negative gate from the plate of V608B is fed to the receiver through jack J605.

SECTION III

RANGE INDICATOR BC-1371

106. BLOCK DIAGRAM.

The coarse and fine range scopes, the range servo drive mechanism, and part of the automatic range tracking circuits are located in the range indicator. A complete block diagram, figure 108, shows the components in the range indicator (fig. 107).

a. Sweep Transformers. The 32,000-yard and 2,000-yard sweep transformers are located in the range indicator near the range-indicator tubes. These transformers step up the low voltage sine wave input from the cable between the range unit and the range indicator to the level necessary for development of a circular sweep that will cover the screen of the range scopes.

b. Indicator Tubes. The indicator tubes are two 3-inch cathode-ray tubes with a special radial deflection electrode inserted into the tube through the screen. The video signals on this electrode repel the electrons and cause humps corresponding to the main pulse and the reflected echoes to appear on the circular trace. Inputs to these tubes are as follows:

(*1*) *Video.* The radar video signals are applied to the radial deflection electrode of the tube. This gives an outward deflection of the trace when the video signals arrive.

(*2*) *Sweep.* The sweep voltages generated in the range unit are applied to the deflection plates of the indicator tubes to produce the circular sweep as explained in paragraph 91. The trace on the coarse range scope is a 32,000-yard timebase; the trace on the fine range scope is a 2,000-yard timebase.

(*3*) *Wide Gate.* To unblank the 32,000-yard range scope for only the first 32,000 yards following the transmitted pulse, the 32,000-yard wide gate is applied to the intensity grid of the coarse range indicator tube. This causes the sweep line to be brightened for only one revolution of the trace and thus eliminates any confusion from signals at ranges greater than 32,000 yards appearing superimposed on signals from ranges less than 32,000 yards.

(*4*) *Narrow Gate.* The narrow gate is used to unblank the fine range scope for only a few hundred yards in the vicinity of the selected target. This gate is used only during NORMAL operation.

(*5*) *N^2 Gate.* The N^2 gate is applied to the cathodes of both indicator tubes during ART operation to brighten the sweep line at the instant of time the receiver gated channel is turned on to admit the selected target signal. The position of the gate spot on the scopes corresponds to the range of the received signal during operation.

(*6*) *Illuminating Gate.* The illuminating gate is applied to the fine range scope during ART operation to brighten the sweep trace for 1,800 yards in the vicinity of the selected target. This gate is necessary, for the N^2 gate appears as a very small spot, smaller than the target signal being received; so in order to observe any interfering signals as well as the selected signal itself, a wider unblanking gate is needed.

c. Range Slewing Handwheel. Range is read from the indicator tubes by observing the posi-

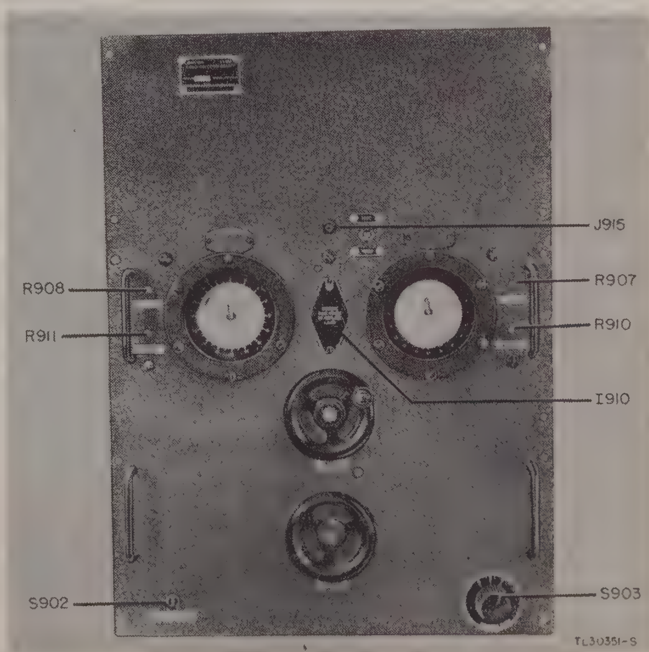

Figure 107. Range indicator, front view.

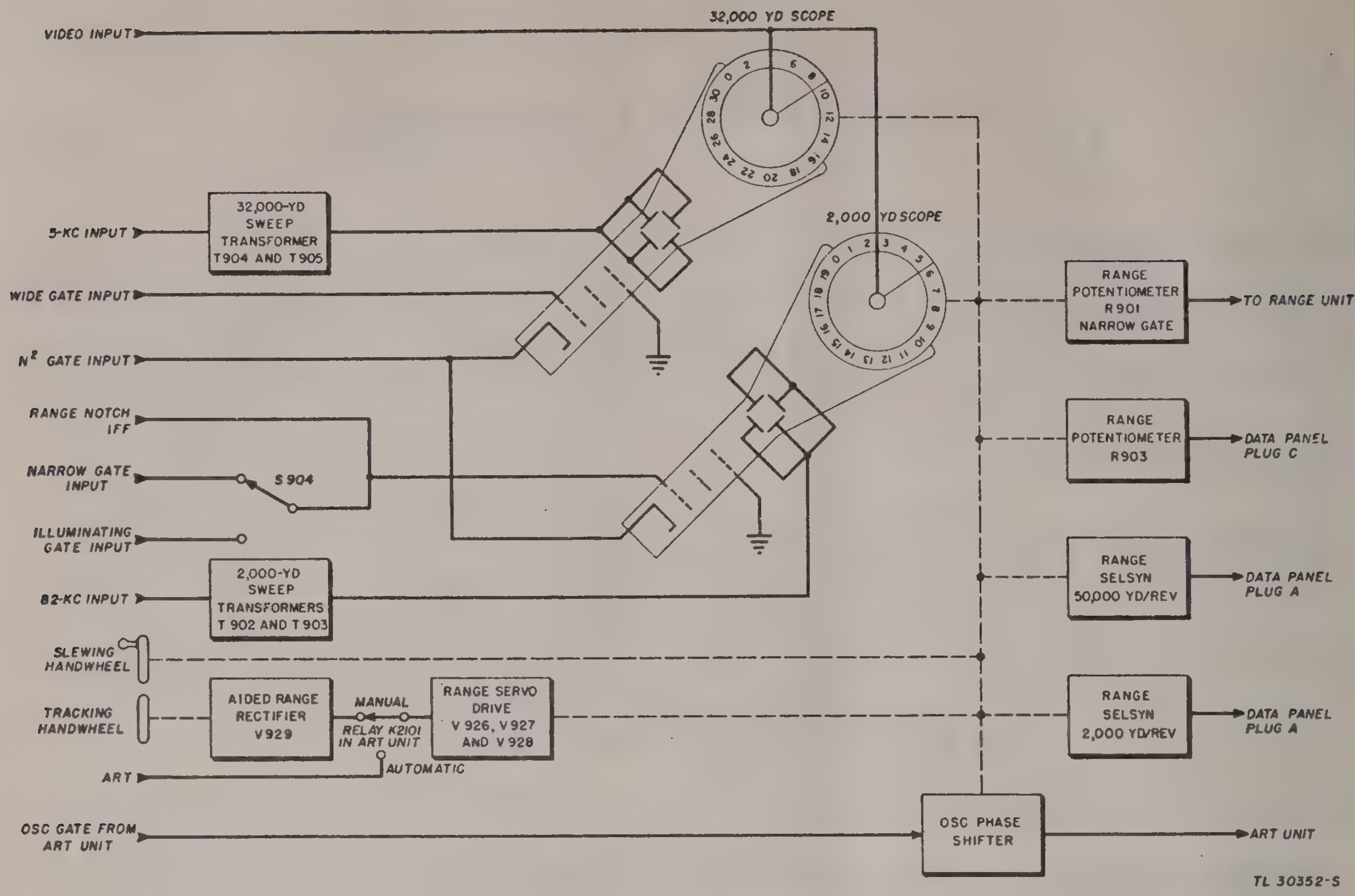

Figure 108. Range indicator, block diagram.

tion of the target signal on the face of the screen. A calibrated ring is mounted around the face of each indicator tube, and a glass cover with a hairline is mounted over the face of the scope. Turning the slewing handwheel causes the transparent cover to rotate, so that it is possible to make the range hairline fall over the target signal and the stationary scale at the rim of the tube. Range is read on the fixed scale where the hairline intersects the scale around the screen.

d. Tracking Handwheel. When the range servo drive motors are not in operation, the function of the tracking handwheel is the same as the function of the slewing handwheel, except that one turn of the slewing handwheel causes the range hairline on the scopes to move 2,000 yards across the range scale, while one turn of the tracking handwheel causes the range hairlines to move only 50 yards on the range scales. During aided tracking operation, this handwheel performs an additional function; it controls the rate of the range tracking motor. Thus, when tracking a target with aided range tracking, if the hairlines should be turning too slowly and drop behind the target, turning the tracking handwheel not only speeds up the motors to correct the difference in rate, but advances the hairlines to make up for difference in position.

e. Aided Range Rectifier. The aided range rectifier is a variac controlled rectifier. By changing the output of the variac (by turning the tracking handwheel), the output of this rectifier becomes unbalanced, the polarity and magnitude of this unbalance being controlled by the amount the tracking handwheel has been turned from the neutral position. This output is fed to the range servo drive circuits to control the rate of the range drive motor during aided range tracking operation.

f. Range Servo Drive. The range servo drive circuit is a balanced thyratron rectifier supplying the armature current to the range drive motor. During aided range tracking, this circuit is controlled by the range tracking rectifier, and during automatic range tracking operation, this circuit is controlled by the automatic range tracking unit.

g. Narrow Gate Potentiometer. The narrow gate potentiometer is driven by the same gear train that drives the range pointers. Its output, a voltage proportional to the setting of the range hairlines, is applied to the narrow gate delay multivibrator (par. 104) to keep the narrow gate at the range indicated by the hairlines.

h. Range Potentiometer. The range potentiometer is also connected to the range gear train. It supplies a voltage output proportional to the position of the range hairlines to jack C at the switch and data panel for the electrical gun directors.

i. Range Selsyns. The range selsyns are geared to the range drive mechanism in such a way that one selsyn makes one turn for 50,000 yards range, while the other makes one turn for 2,000 yards range. These selsyns are electrically connected to jacks A and B on the switch and data panel to supply range data.

j. Oscillator Phase Shifter. The oscillator phase shifter capacitor is geared to the shaft of the range slewing handwheel. Thus, as the range drive mechanism is turned, either manually or by the range drive motors, the phase of the oscillator is continuously varied. Details of the operation of this circuit and its purpose are discussed in section IV of this chapter where the automatic range tracking unit is discussed.

107. RANGE SCOPES.

The two range indicator tubes used in the range indicator are 3-inch screen, electrostatic deflection cathode-ray tubes. These tubes are similar to the conventional cathode-ray tube, but with an additional electrode for deflecting the beam radially. This electrode passes through the screen of the tube and extends inward along the axis of the tube as shown in figure 109.

a. Sweep Circuits (fig. 115). The circuits that generate the sweep voltages are located in the range unit and have been described in paragraph 91. The sweep voltages were reduced to a low value in the range unit when the output impedance of the range unit sweep circuits was matched to the impedance of the cables between the range unit and the range indicator. The sweep transformers in the range indicator are used to step up these sweep voltages to the value required to produce a circular sweep of 2 inches in diameter. These transformers are tuned by movable powdered iron plugs. Each of the sweep transformers contains a network for applying a centering voltage to the deflection plates.

b. Centering Circuits. The centering controls are located on the range unit, but for purposes of explanation, they are shown in the range indicator simplified schematic diagram (fig. 115). One of each of the deflection plates is connected to ground through a high resistance in the sweep transformer (for example, R923). The other deflection plate is connected to the centering potentiometer through an isolating resistor (R924 for example). The centering potentiometers are connected between points in the range unit that are at +100 volts and − 100 volts potential. In this way, the voltage between each pair of deflection plates can be set anywhere from − 100 volts to +100 volts to center the circular sweeps.

c. Voltage Supplies. Approximately 2,000 volts are required for the operation of the cathode-ray tubes. This voltage is obtained from the high-voltage rectifier in the range unit power

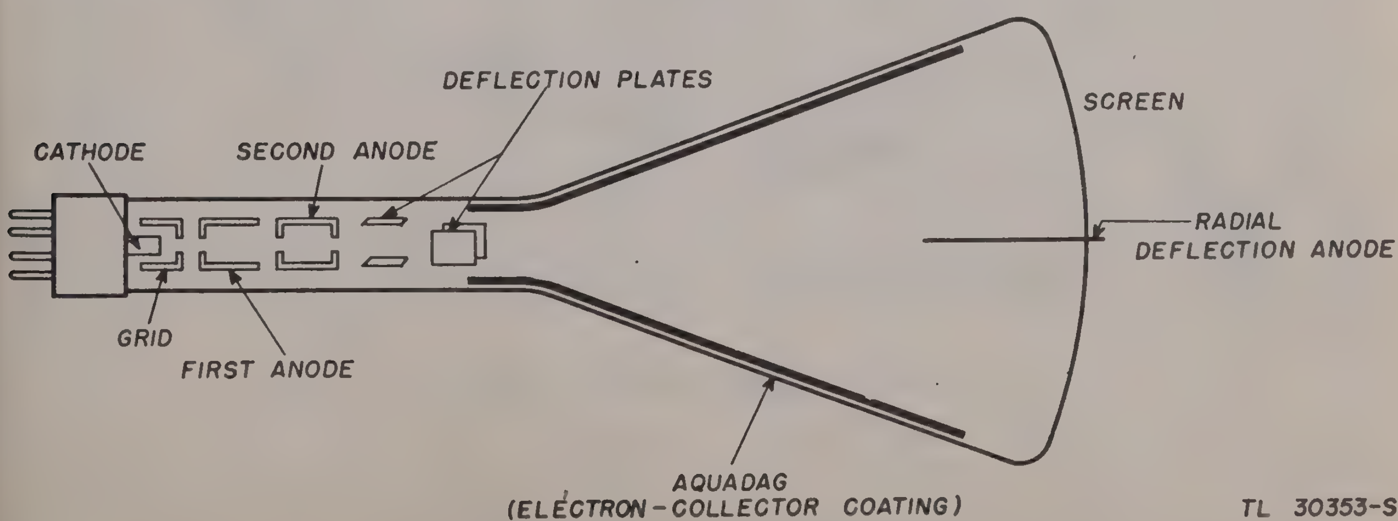

Figure 109. Range indicator tube.

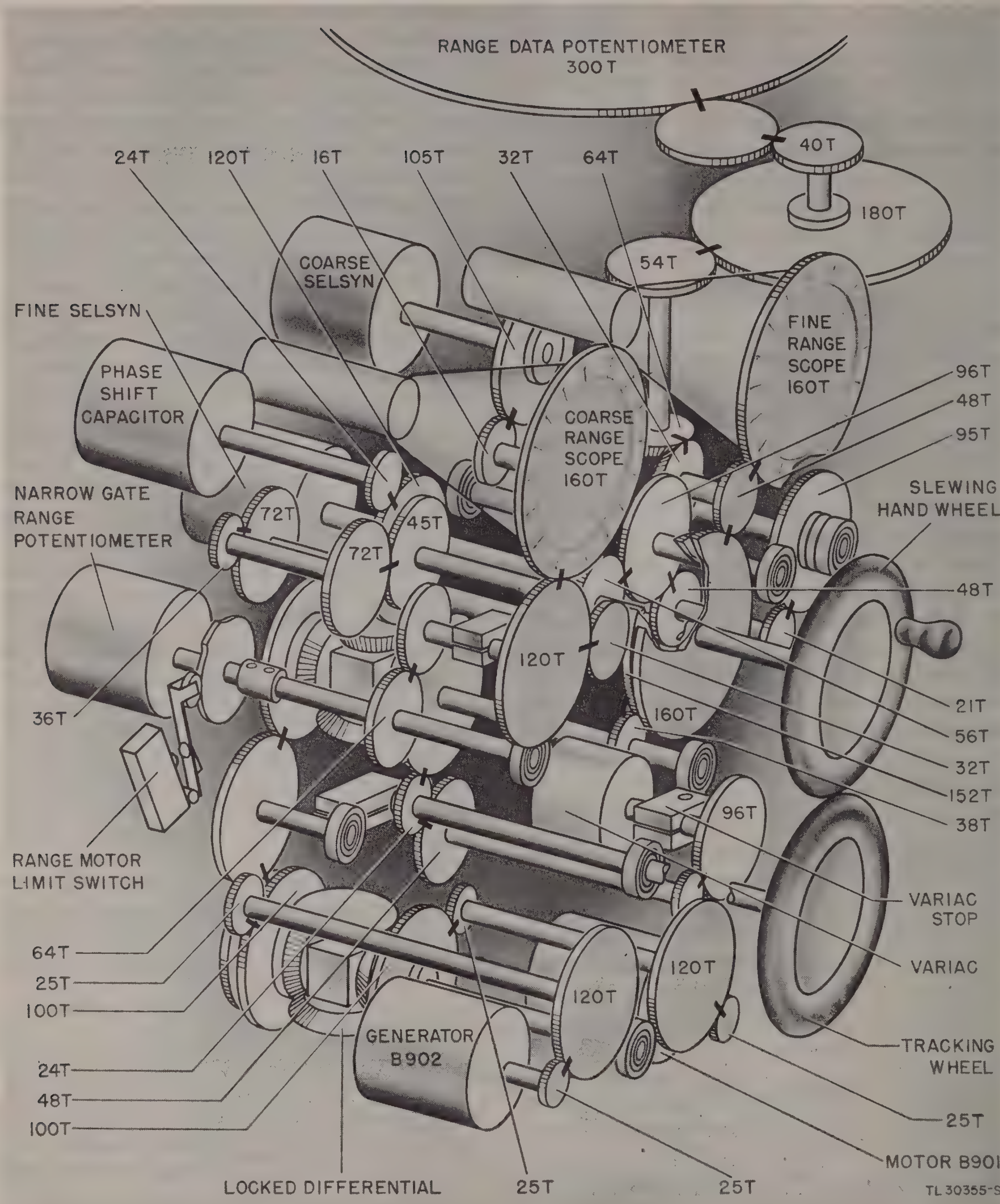

Figure 110. Range indicator, cut away view.

supply. The positive side of this supply is grounded and the − 2,000 volts is applied to the cathodes of the tubes. This enables the deflection plates and the center radial deflection anode to be operated at ground potential.

d. Intensity. The intensity of the spot on the screen of the cathode-ray tubes depends upon the speed of the electrons, fixed by the second anode voltage, and the number of electrons that strike the screen at one time. The two INTENSITY controls in the range indicator set the grid bias in the electron gun part of the cathode-ray tubes, and thus control the number of the electrons in the beam. The wide gate, narrow gate, and illuminating gate, also applied to the grids of the tubes, lower the grid bias momentarily to allow the trace to become visible for a short time. The combined setting of the intensity control and the gate applied to the grid determine the brilliance of the trace. The N^2 gate, applied to the cathodes, brightens the trace in a similar manner.

e. Focus. Adjusting the focus controls, R908 and R907, varies the electric field between the first and second anodes. The field between these anodes determines the point at which the electrons making up the beam converge. When the intensity controls are operated, the focus controls should be set for the sharpest sweep line.

108. RANGE INDICATOR GEAR TRAIN.

The range indicator gear train is shown in figure 110. There are five gears 160T, 152T, 56T, 45T and 120T on the slewing handwheel shaft.

a. The gear (160T) on the front of the shaft just behind the handwheel drives the hairline around the fine range indicator tube; one turn of the handwheel turns the hairline once around the indicator (2,000 yards). The range data potentiometer R903 gear train is also driven by this front gear through the 48T and 32T gear. The potentiometer gear train reduces the motion of the slewing handwheel so that 15 turns of the handwheel which corresponds to 30,000 yards range, turns the potentiometer through 360 degrees. The last turn of the handwheel (30,000 yards to 32,000 yards) turns the potentiometer shaft further, but a spring in the potentiometer allows the shaft to turn without moving the potentiometer arm over the stop.

b. The gear (56T) just behind the front subpanel on the slewing handwheel shaft drives the selsyn reduction gear train. The fine range selsyn is geared thruogh a 1 to 1 ratio to the handwheel shaft; one turn of the handwheel (2,000 yards) causes the selsyn shaft to make one turn. The coarse selsyn is geared down to 50,000 yards per revolution through the 96T, 48T, 21T, 95T, 16T and 105T gears; one turn of the handwheel turns the selsyn 1/25 turn.

c. The gear (45T) on the handwheel shaft just forward of the rear subpanel drives the reduction gear train that turns the hairline around the face of the coarse range scope and drives the narrow gate range potentiometer. This train drives the coarse range hairline at a reduction ratio of 16 to 1 through the 72T, 36T, 72T, 32T, and 120T gears; 16 turns of the handwheel correspond to 32,000 yards range. The narrow gate potentiometer is geared to the shaft so that when the handwheel is turned through 32,000 yards range, the potentiometer is turned through 270 degrees. An adjustable coupling on the potentiometer shaft allows the potentiometer to be oriented with the 32,000-yard range scope. A mechanical stop on the shaft of the reduction gear train prevents the handwheel shaft from being turned beyond the 32,000-yard limit. A friction clutch on the handwheel keeps the operator from shearing off the stops by the shaft after the stops have been reached. A cam and limit switch on the potentiometer shaft shut off the range drive motor at the zero and 32,000-yard ends of the hairline travel.

d. The gear (120T) on the end of the handwheel shaft drives the phase shift capacitor. One turn of the handwheel turns the capacitor shaft five times. This gear forms part of a friction clutch assembly that couples the range drive motors and the range tracking handwheel to the main drive shaft. The clutch arrangement is to prevent damage to the stop on the narrow gate gear train potentiometer if the tracking handwheel were turned after the stop was reached.

e. The 152-tooth gear on the slewing handwheel shaft is friction-clutch coupled to the shaft. This gear is driven by a differential gear train. The differential has two input gears and one output gear. One input gear is driven by the range drive motors through the locked differential. The other input gear is driven by a gear (24T) on the tracking handwheel shaft. The rate that the output gear turns depends upon the speed and direction of each of the input gears. The speed and direction of the motor is controlled by the variac which is driven by the tracking handwheel. A brake on the tracking handwheel shaft prevents the drive

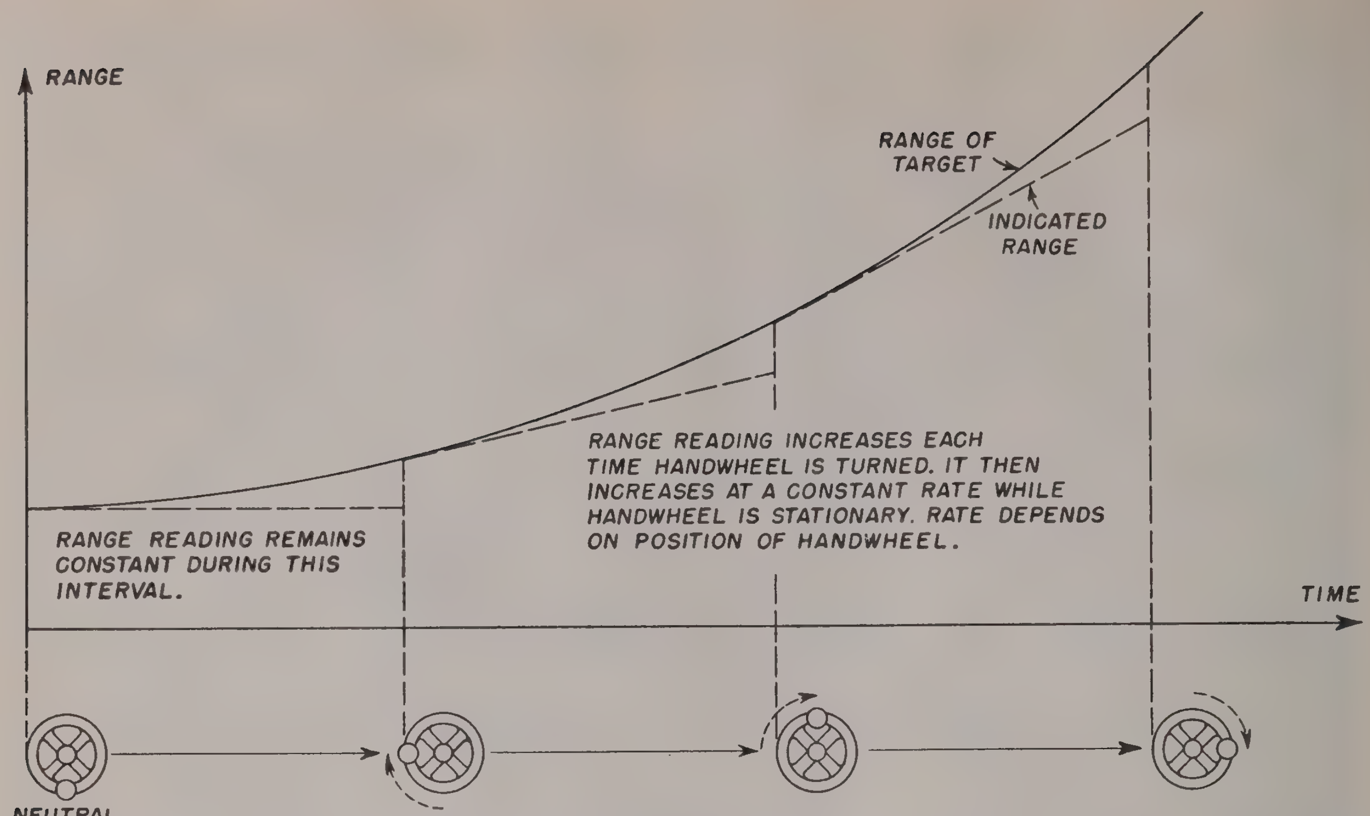

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Figure 111. Effect of rotating tracking handwheel.

motors from turning the tracking handwheel through the differential. The differential causes the pointers to be turned towards the on-target position when turning the tracking handwheel to correct the aided tracking rate. When the tracking handwheel is displaced from its neutral position, the range hairlines are displaced by an amount proportional to the rotation of the handwheel shaft. At the same time, the rotation of the aided tracking handwheel changes the variac setting so as to change the speed of the drive motor. The effect of the tracking handwheel is shown in figure 111. The coupling through the differential causes the range hairlines to move as the handwheel is turned, and the coupling to the variac causes the speed of the drive motor to change. The locked differential merely couples the range motor B901 and generator B902 together and through an idler gear to the unlocked differential.

109. AIDED TRACKING RECTIFIER.

The aided tracking rectifier is shown in the simplified schematic diagram figure 112. The voltage applied to the rectifiers depends upon the setting of switch S903, the TRACKING RATIO switch. When this switch is in the position marked 1, the voltage applied is minimum: maximum voltage is applied when the tracking ratio switch is in the position marked 1/3. The aided tracking rectifier is composed of two half-wave rectifiers and R-C filters, developing their outputs across load resistors R926 and R927. When the variac is set in its midposition, the voltage applied to each rectifier tube is equal, and the two rectified outputs are equal. When the variac is set to one end of its travel, the output of one rectifier is zero, while the output of the other is doubled. The outputs of these rectifiers are amplified in the next stage. To set the operating point of the next stage, the neutral point is not grounded, but connected to +50 volts dc. This stage is used only during aided range tracking operation. The relay that connects this stage to the servo drive amplifier is located in the automatic range tracking unit.

110. RANGE SERVO DRIVE.

The range servo drive consists of a balanced d-c amplifier and a thyratron rectifier stage supplying armature current to the range drive motor. The amplifier input circuit is an R-C filter to smooth the output of the range rectifier or the automatic range tracking unit. The output of the amplifier is developed across load resistors R929 and R930. Degenerative feedback is applied to this amplifier through the cathodes. A generator, connected to the

range drive motor, generates a voltage proportional to the speed of the range drive motor. If, because of any irregularities in the range drive gearing or line voltage changes, the speed of the drive motor should change, the feedback voltage changes in such a way as to cause the servo circuits to return the motor to its original speed.

a. Amplifier. The voltage divider R935 and R942 (fig. 113) set the ground point of the aided range tracking rectifier to 50 volts above the ground point of the amplifier. When the outputs of each section of the rectifier are equal, the grids of both sections are held at 85 volts above ground. This causes equal plate current to flow in both sections of the amplifier. Both amplifier plates are at 150 volts above ground, and the common cathode resistor R928 is at approximately 100 volts above ground. The outputs of the amplifier (the plate voltages) are used to control the thyratron rectifier stage. When both amplifier plate voltages are equal, the thryatrons do not cause the range drive motor to rotate. When the grid voltage of one section is increased, by changing the rectifier output, the grid voltage of the other section is decreased by the same amount. The tubes amplify this change. The potential at the ungrounded end of the common cathode resistor remains essentially unchanged, for the increased current in one section of the tube is counterbalanced by the decrease in current through the other. The unbalanced plate voltages cause the thyratrons to run the drive motor. The motor turns the generator, and a voltage is applied to the cathodes that is proportional to the speed of the range motor. This generator voltage causes additional current to flow through the cathode resistors R940 and R941 in such a way that the cathode of the section, whose grid is most positive, is made more positive than the ungrounded side of the common cathode resistor, while the voltage at the other cathode is made more negative. Then, if the speed of the drive motor should change for any reason whatsoever, the voltage at the most positive cathode drops, while the voltage at the other cathode rises. This increases the bias on one tube and decreases the bias on the other, and further increases the voltage at the amplifier plate, already more positive, and decreases the voltage at the other plate, controlling the thyratrons in such a way as to increase the drive motor current and speed.

b. Thyratron Rectifier.

(*1*) *Thyratron Tubes.* The thyratron tubes used in the range servo drive system are gas filled tetrodes. The control grid in this tube acts as a switch to turn the tube on. Once the tube starts conducting, the control grid no longer affects the flow of plate current. Even if the grid voltage should drop below the critical value required to start conduction, the plate current will not cease. Thus, conduction in the thyratron starts when the grid voltage rises above the critical value, and continues until the plate voltage drops to zero, regardless of the voltage on the grid during the conduction period. The operating voltage waveforms of the rectifiers in the range servo drive system are shown in figure 114. The voltage applied to the grid is composed of a sine wave and d-c voltage.

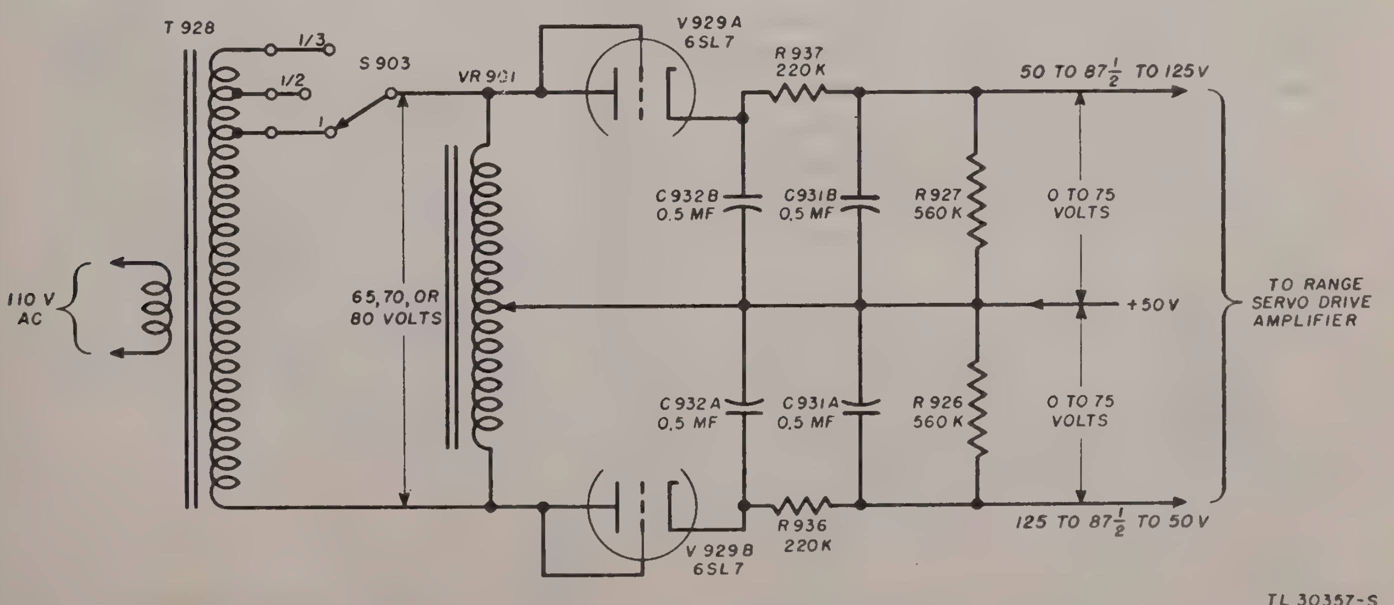

Figure 112. Aided tracking rectifier.

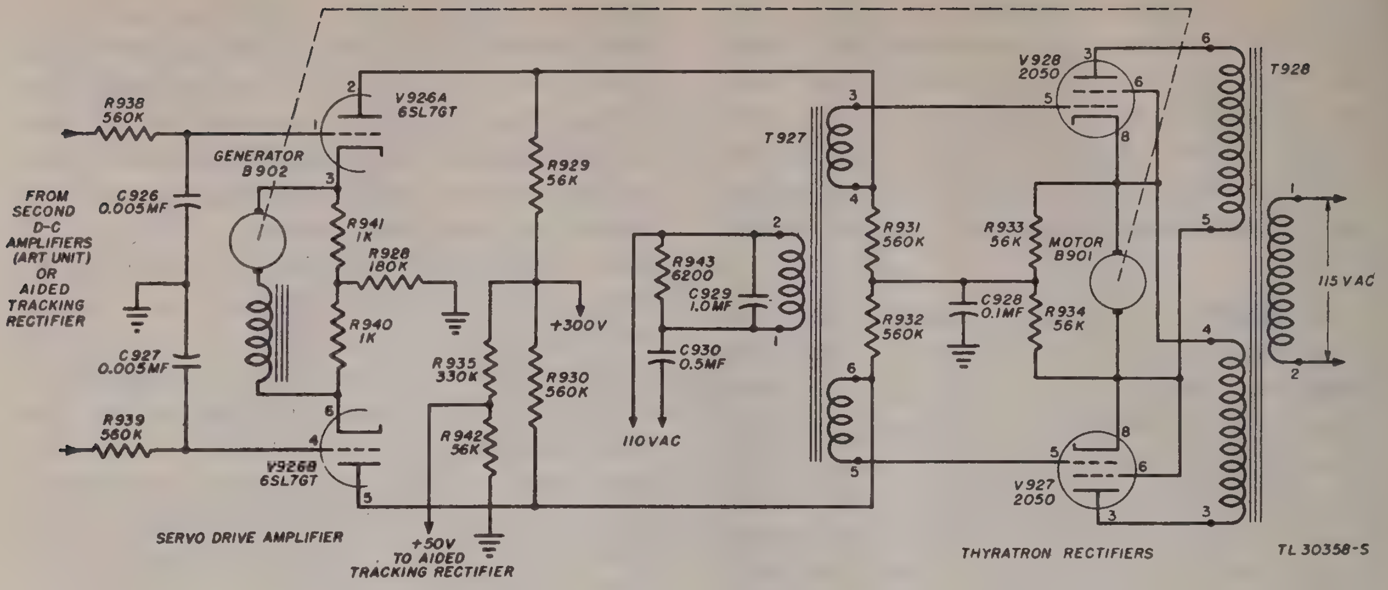

Figure 113. Servo amplifier and thyratron rectifiers, simplified schematic diagram.

The amplitude of the sine wave is fixed, but the d-c level is variable. It is seen from these waveforms that by changing the d-c input to the stage, the length of time that the thyratron conducts, is varied and thus the rectified current is varied.

(2) *Control Transformer.* The control transformer T927 provides the 50-volt peak a-c voltage that is applied to the grids in series with the d-c output of the amplifier V926. Without the phase shifting network R943, C930, and C929, the plate and grid voltages would be phase or 180 degrees out-of-phase, depending on the transformer connections, and the only control of the thyratron conduction would be on-off control, or complete conduction-time control. The phase shifting network and the transformer connections make the grid voltage lag the plate voltage by 135 degrees. This is the condition shown in figure 114. From figure 114 it can be seen that as the d-c level of the sine wave is raised or lowered by the amplifier output, the conduction time increases or decreases smoothly.

(3) *Operation.* When the tracking handwheel is set so that the range motor tracking rate is zero, the outputs of the amplifier are balanced. This means that both the thyratron tubes conduct the same amount of current. The tubes are connected so that the plate current of each tube must flow through the drive motor in an opposite direction. When both tubes are drawing the same current (the balanced condition) the current of one tube through the drive motor cancels the effect of the current of the other tube, so that the motor will not turn. However, when the range tracking handwheel is turned to feed a tracking rate to the motor, the rectifier and the amplifier put a voltage on the thyratron grids so that the conduction time of one thyratron is more than the conduction time of the other; the thyratron currents through the motor are no longer equal, and the motor is turned by the larger current. When the ampli-

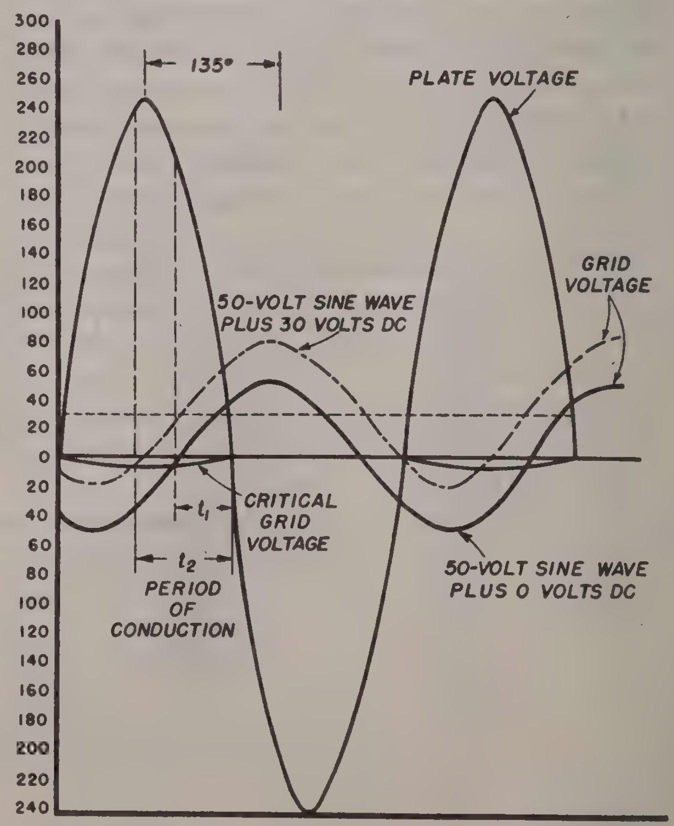

Figure 114. Thyratron rectifier waveforms.

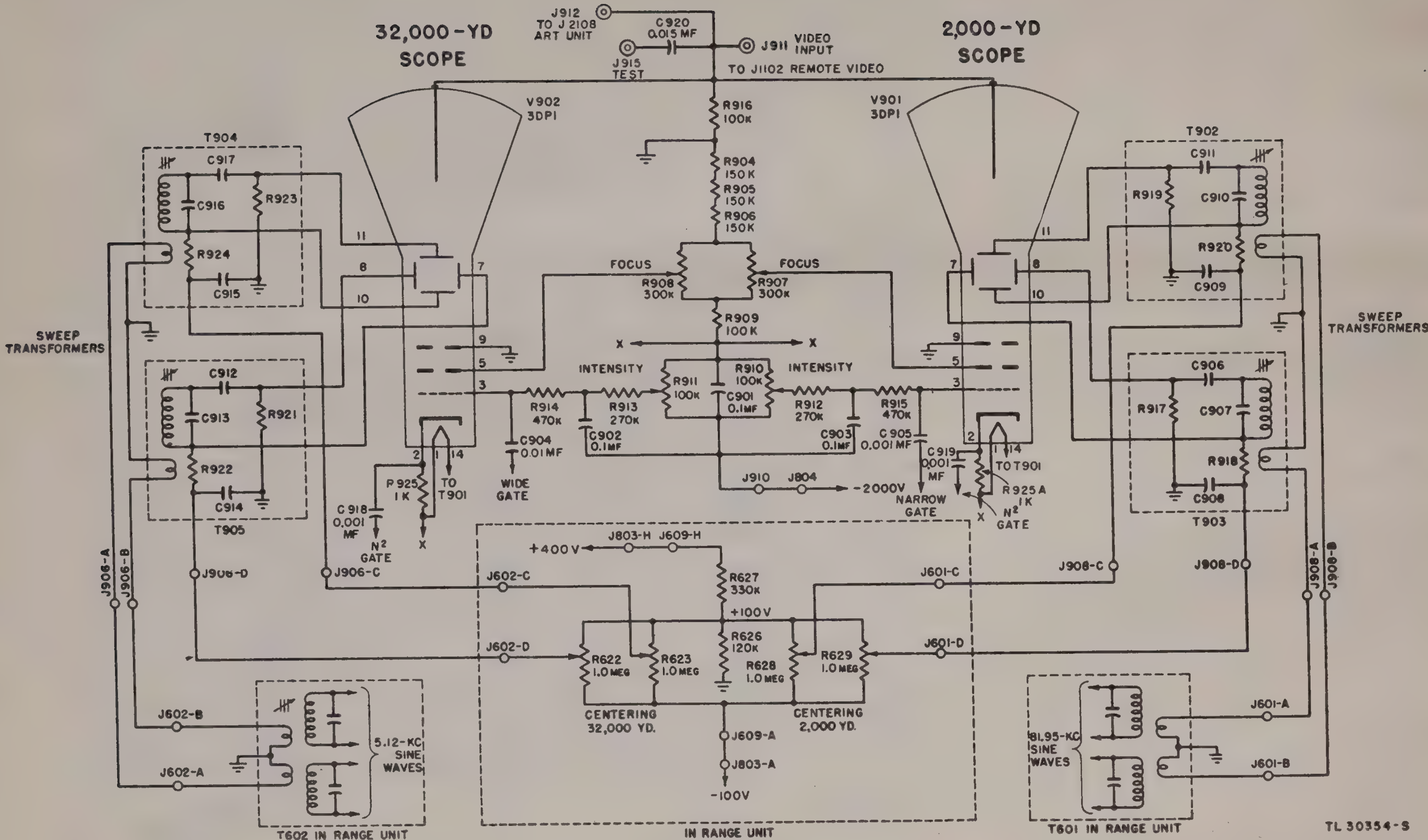

Figure 115. Range indicator, partial schematic diagram.

fier controls the thyratrons so that tube V927 conducts more, the drive motor is driven in the direction of decreasing range. When V928 conducts more than V927, the motor turns in the opposite direction, or in the direction of increasing range. Resistors R931, R932, R933, and R934 and capacitor C928 set the cathode voltage level of the thyratron rectifier stage to get full advantage of the output of the balanced d-c amplifier.

SECTION IV

AUTOMATIC RANGE TRACKING UNIT

111. BLOCK DIAGRAM (fig. 117).

There are two tracking channels in the automatic range tracking unit (fig. 116): the gate tracker channel, and the servo tracker channel. The gate tracker holds the gate that turns the receiver on and off during ART operation (the N^2 gate) coincident with the selected target echo signal. The servo tracker keeps the range hairlines over the N^2 gate signal on the range indicator tubes. During manual operation, the servo tracker is not used. The range servo drive circuits are controlled by the tracking rectifier in the range indicator unit instead, and the gate tracker does not track the target signal, but tracks instead the N^2 gate by means of the delayed sine wave from the range indicator.

a. Input Multivibrator. Input multivibrator V2210 is triggered by a negative trigger from the range unit. This trigger occurs at the same instant as the transmitter trigger and the PPI trigger from the range unit. The input multivibrator generates a positive-going square wave that is used to start the sine wave oscillator in the range indicator unit and a negative-going square wave to

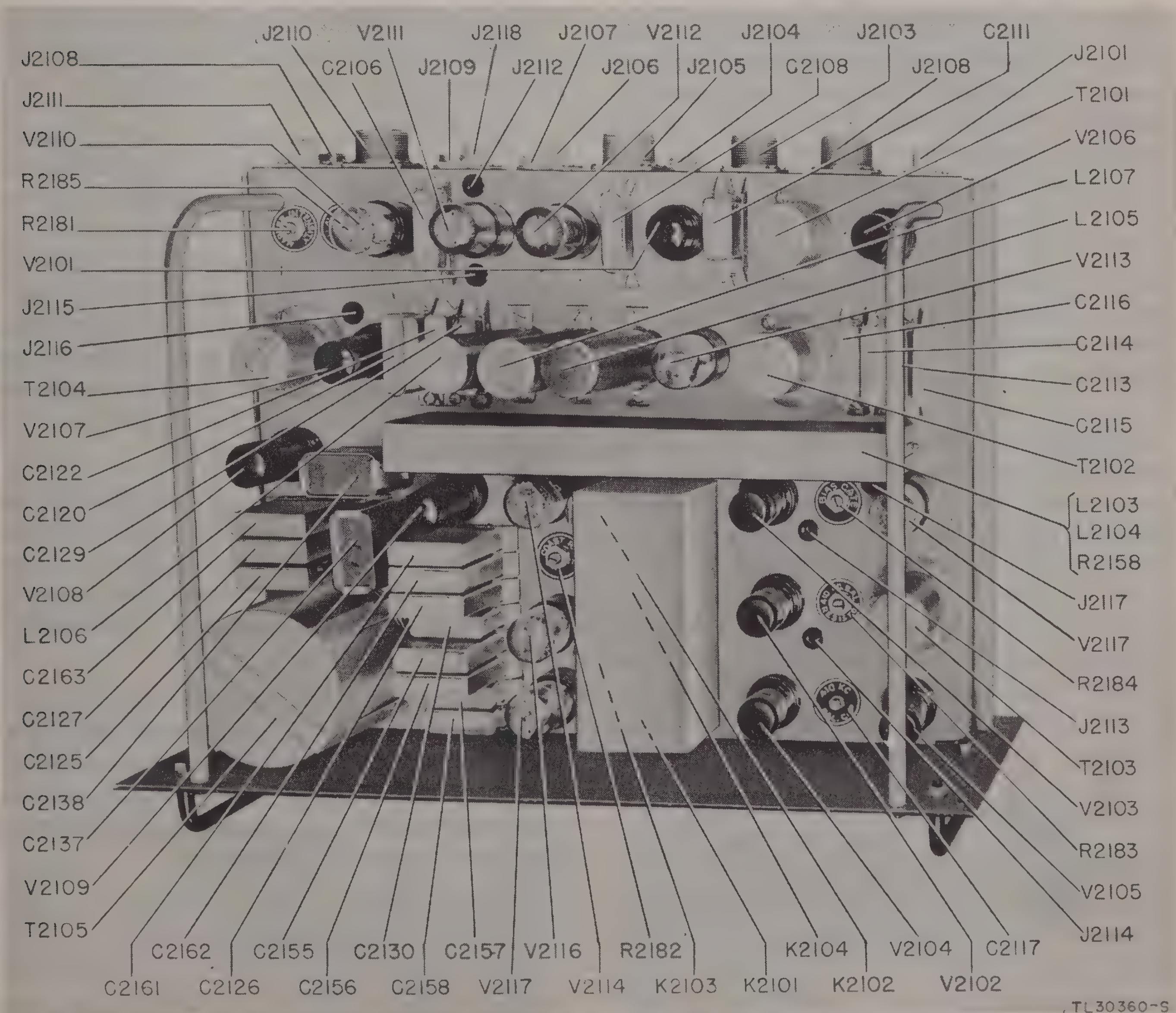

Figure 116. ART unit, top view.

operate the delay circuit in the automatic range tracking unit. This multivibrator turns these circuits on for a time corresponding to the first 45,000 yards, and keeps them inoperative for the remaining 45,000 yards of the transmitter operating cycle.

b. Saw-tooth Delay. The saw-tooth delay voltage is generated by applying the output of a trapezoidal voltage generator to a diode V2112B with a control voltage bias on it. This control bias keeps the diode in the nonconducting state until sufficient time has passed for the trapezoidal voltage to build up to a value exceeding the control bias on the diode, at which time the diode can conduct. The output of this stage is a saw-tooth voltage whose starting time is controlled by the control bias.

c. Differentiator and Amplifier. The differentiator and amplifier V2106 differentiates, amplifies, and pips the output of the saw-tooth generator. The result of the first differentiation is a rectangular wave whose leading edge occurs after the delay time set by the control bias. This rectangular wave is amplified and a negative and a positive pip is generated, the negative pip occurring after the end of the controlled delay, and the positive pip occurring at 45,000 yards. The negative pip, whose appearance is timed by the control bias, is used to trigger the illuminating gate generator.

d. Illuminating Gate Generator. The illuminating gate generator V2113 is a single swing blocking oscillator. It is triggered by the delayed negative trigger from the differentiator and amplifier and generates the 1,800-yard gate that is used to unblank the 2,000-yard scope and to trigger the N^2 gate generator through a delay line L2105 which delays the pulse 2.1 microseconds. This delay is necessary so that the selected target will appear in the center of the 1,800-yard illuminating gate.

e. N^2 Gate Generator. The delayed gate from the illuminating gate generator, differentiated in the coupling circuit, triggers the N^2 gate blocking oscillator V2107. This single swing blocking oscillator generates the 0.3 microsecond (50 yards) gate and turns on the receiver to pass the selected target signal. This gate signal is applied to the range indicator to indicate the time that the receiver gated channel is turned on. The gate signal is passed through a delay line L2104 and applied to the gate tracker V2102 and V2103 and to the servo tracker V2115. The purpose of the delay line is to compensate for the delay in the receiver cable and thus insure that the tracking tubes operate at the same instant that the gated receiver channel operates.

f. Gate Tracker.

(*1*) During automatic range tracking operation, the gate tracker receives two signals: a split video signal, and the N^2 gate signal. The tracker charges up or discharges a storage network to provide the control bias for the saw-tooth delay circuit. If the gate is centered between the split video signal, the voltage on the storage network is not changed. If the N^2 gate is at a greater range than the video signal, the tracker causes the storage network to discharge and lower the control voltage enough to decrease the delay time of the delay circuit and bring the N^2 gate up to the proper time relationship with the split video signal.

(*2*) During manual range tracking operation, the push-pull output of the sine-wave amplifier V2104 and V2105 is substituted for the split video signal in the gate tracker. Then, as the range handwheel is turned either by hand or by the range motor, the phase of the sine wave shifts and causes the gate tracker to move the N^2 gate so that it is at the leading edge of the target echo. If the unit is aligned properly, the range hairline will be over the N^2 gate and the correct range will be transmitted.

g. Video Peaker. Video peaker V2108 is an amplifier stage with an L-C peaker in its input circuit, and a compensating inductance in its plate load. This stage converts the 1 microsecond video pulses to pulses 0.3 microsecond wide.

h. Video Splitter. The video splitter is a cathode follower that drives a 0.3 microsecond delay line. The outputs from this stage are taken from each end of the delay line, thus providing two images of the same video signal separated from each other by 0.3 microsecond.

i. Oscillator Gate Cathode Follower. A positive 45,000-yard gate taken from the input multivibrator is applied to the oscillator gate cathode follower V2111A to provide an impedance match to the cable that goes from the automatic range tracking unit to the 410-kc oscillator in the range indicator unit.

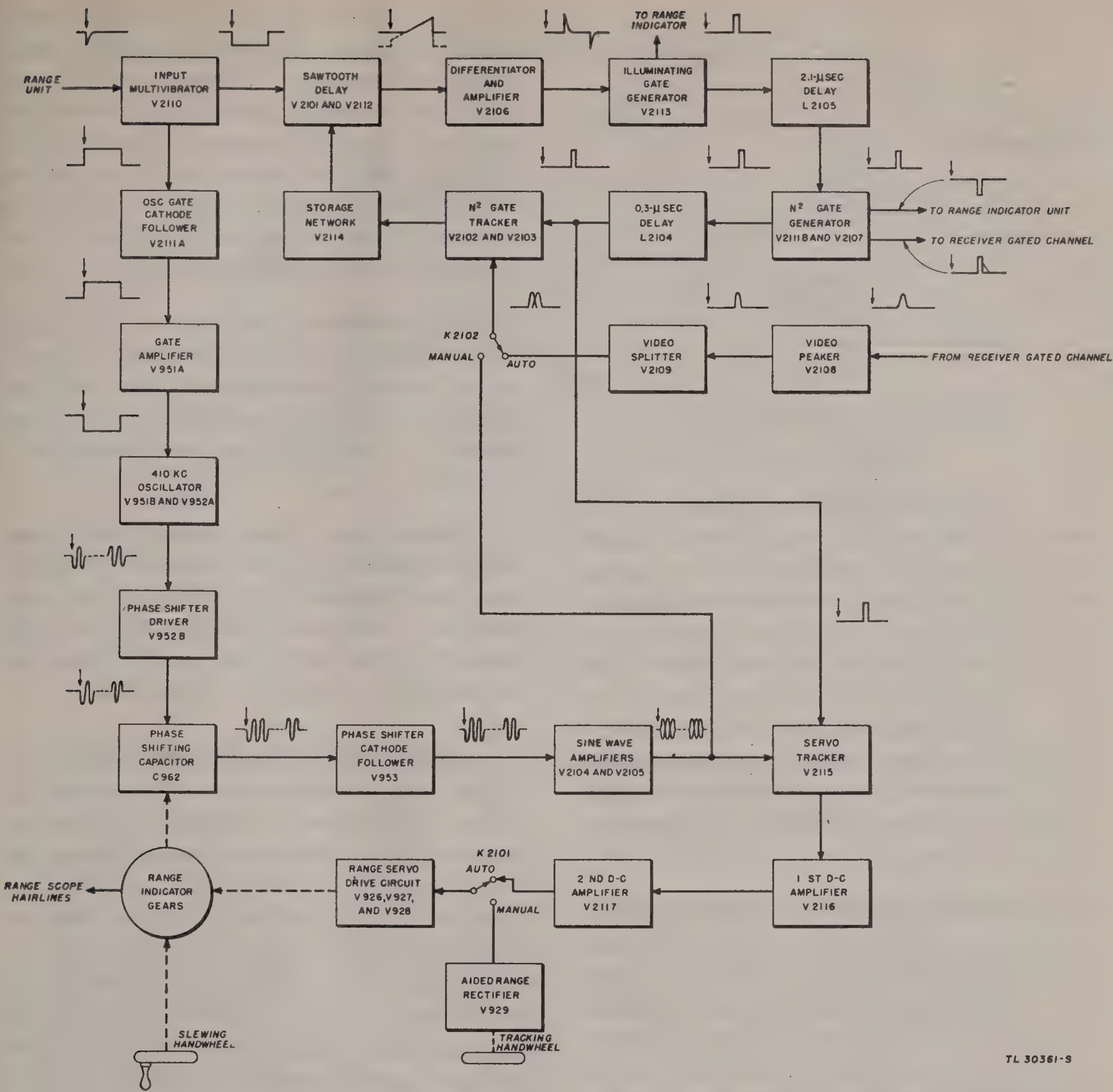

Figure 117. ART unit, block diagram.

j. Oscillator Gate Amplifier. The oscillator gate amplifier V951A is located in the range indicator. It steps up the low-voltage gate signal from the automatic range tracking unit to the value necessary to operate the shock-excited oscillator in the range indicator unit.

k. 410-kc Oscillator. The shock-excited oscillator includes the switch tube V951B that starts 410-kilocycle oscillations in the resonant circuit and oscillator tube V952A that maintains the oscillations in the tank circuit. This circuit oscillates only during the first 45,000 yards of range following the transmitted pulse.

l. Driver. This stage V952B consists of a triode connected as a cathode follower with a transformer load. R-C voltage dividers connected across the transformer secondary provide the phase shift required.

m. Phase Shifting Capacitor. The phase shifting capacitor C962 is a special capacitor with two parallel circular plates; one plate is divided into four separate segments each connected

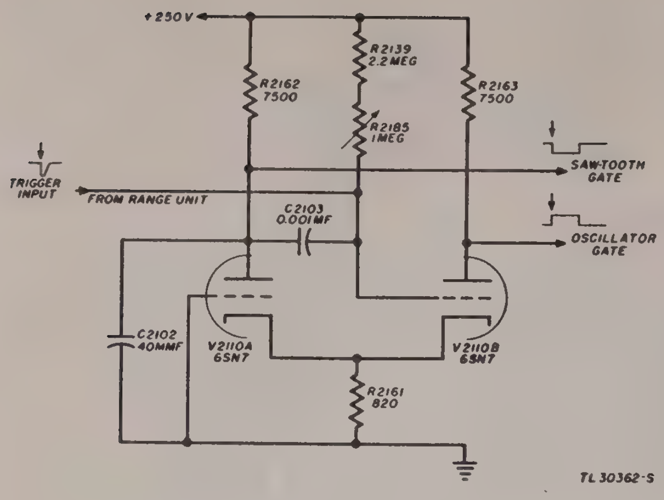

Figure 118. Input multivibrator.

to a 90-degree out-of-phase voltage, and the other is a solid ring. A piece of dielectric material attached to a shaft through the capacitor changes the capacitance between plates of the capacitor in such a way that as the shaft is turned through 360 degrees, the phase of the signal picked up on the solid ring plate is displaced through 360 degrees. This capacitor is coupled to the range slewing handwheel through a 5 to 1 reduction gear train. One fifth turn of the handwheel causes the phase shift output to shift 360 degrees.

n. Amplifiers. The phase shifter is followed by the phase shifter cathode follower V953 and two stages of amplification V2104 and V2105. The phase shifter cathode follower is used to reduce the output impedance of the phase shifter to match the impedance of the cable between the range indicator and the automatic range tracking unit. The first stage of amplification V2104 is located in the automatic range tracking unit and is used to raise the voltage of the signal received from the range indicator. The second stage of amplification V2105 provides balanced push-pull output necessary for the operation of the tracker stages. The output of this amplifier controls the servo tracker during automatic operation, and controls the N^2 gate tracker during manual operation.

o. Servo Tracker. Servo tracker V2115 and the d-c amplifiers that follow it are used only during automatic range tracking operation. The servo tracker output depends upon the time relationship of the N^2 gate and the sine wave output of the phase shifter. During automatic operation, the gate tracker changes the range (time of occurrence) of the gate. As the range of the gate is changed by the gate tracker, the servo tracker output changes. The changed output causes the servo drive circuits to move the range indicator hairlines and to change the phase of the sine wave, restoring the time relationship between the gate and the sine wave.

p. D-c Amplifiers. Two stages of d-c amplification V2116 and V2117 follow the servo tracker to raise the voltage to a level sufficient to operate the servo drive circuits in the range indicator. These amplifiers provide a balanced d-c output.

q. Range Servo Drive Circuits and Range Indicator Gearing. These components have already been discussed in the section on the range indicator. They were included in this block diagram to show their part in ART operation and automatic range tracking operation.

112. INPUT MULTIVIBRATOR (fig. 118).

The input multivibrator is a conventional one-shot multivibrator with the addition of capacitor C2102 to increase the steepness of the square wave output of the stage. In the absence of the capacitor C2102, the operation would be as follows: the grid of tube V2110B is returned to the B+ supply. This holds that section in the conducting state. The current in that section causes the voltage at the common cathodes to rise to approximately 25 volts above ground. This cathode voltage is sufficient to hold section V2110A beyond the cut-off point, for its grid is grounded. The negative trigger from the range unit is applied to the grid of the conducting stage V2110B, tending to drive that stage to cut-off. This decreases the current through that section, thus decreasing the cathode voltage. The decrease in cathode voltage allows section V2110A to start conducting, lowering the voltage at the plate of that section. This decrease in plate voltage is applied through capacitor C2103 to the grid of section V2110B to aid the initial action of the negative trigger from the range unit. This process continues until section V2110A is conducting heavily and section V2110B is cut off. The multivibrator

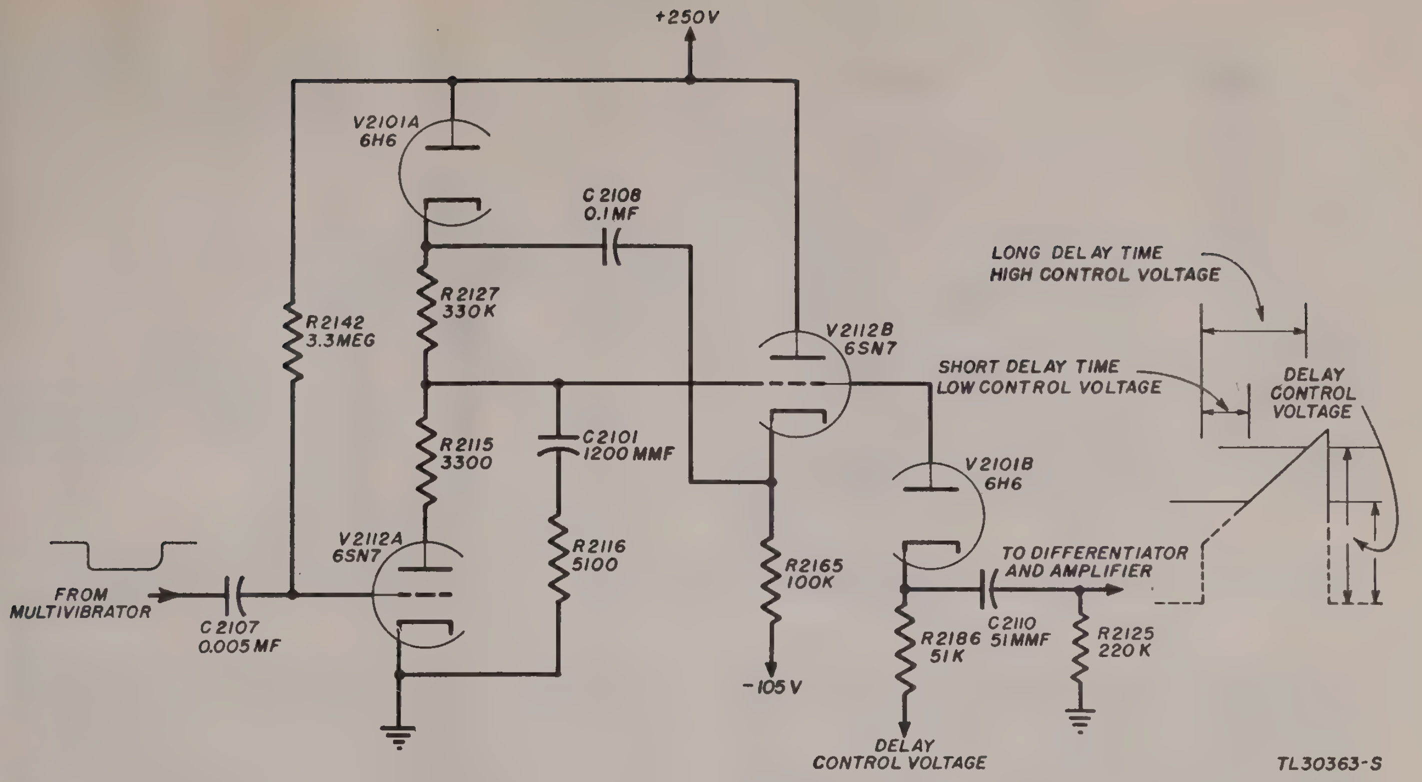

Figure 119. Saw-tooth delay circuit.

remains in this state of operation until the charge on capacitor C2103 can leak off through resistors R2139 and R2185, and raise the voltage at the grid of section V2110B to a high enough level to allow that stage to conduct and restore the multivibrator to its normal condition. The input trigger not only causes the grid voltage of section V2110B to drop, but also, because of coupling through capacitor C2103, causes the plate voltage of section V2110A to drop. Adding capacitor C2102 to the circuit tends to hold the plate voltage of section V2110A at the initial B+ value of 250 volts, thus causing the initial flow of plate current to be stronger because of the higher plate voltage at the start of the multivibrator cycle. This capacitor must be small enough to prevent too much rounding of the square wave output by the shunt capacity introduced, and large enough to hold the plate voltage up during the arrival of the negative trigger. The output of this multivibrator is a square wave of 1.707-kc recurrence frequency. The negative 45,000-yard output is applied to the saw-tooth delay circuit, and the positive 45,000-yard output is applied to the oscillator in the range indicator unit through the oscillator gate cathode follower V2111A. Resistor R2185 controls the discharge time of capacitor C2103 and is set to give a symmetrical output. This adjustment is made best using the test oscilloscope to observe the waveform at test jack J2112 while the MAX RANGE ADJUST R2185 control is varied.

113. SAW-TOOTH DELAY CIRCUIT (fig. 119).

The saw-tooth delay circuit is made up of a bootstrap trapezoidal voltage generator V2112A, V2112B, and V2101A, and a pick-off diode V2101B.

a. Bootstrap Trapezoidal Voltage Generator (fig. 119).

(*1*) Tube V2112A is held in a heavily conducting state by connecting its grid to B+ through resistor R2142. Tube V2101A in the plate circuit serves only to isolate the plate of tube V2112A from B+ during the bootstrap cycle at which time the plate voltage of V2112A rises above the B+ value. With V2112A conducting heavily, the voltage drop across capacitor C2101 and resistor R2116 will be small.

(*2*) When the negative gate from the input multivibrator is applied to the grid of V2112A, that tube will be cut off, allowing capacitor C2101 to charge up. The voltage across capacitor C2101 and resistor R2116 differs from a simple capacitor charging curve in that an

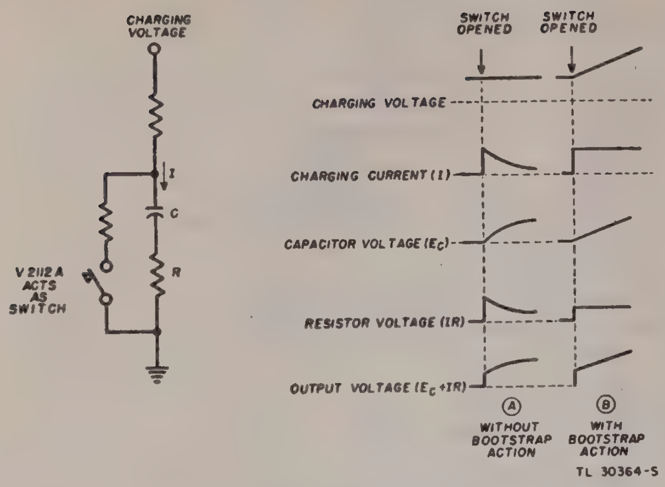

Figure 120. Trapezoidal generator operation.

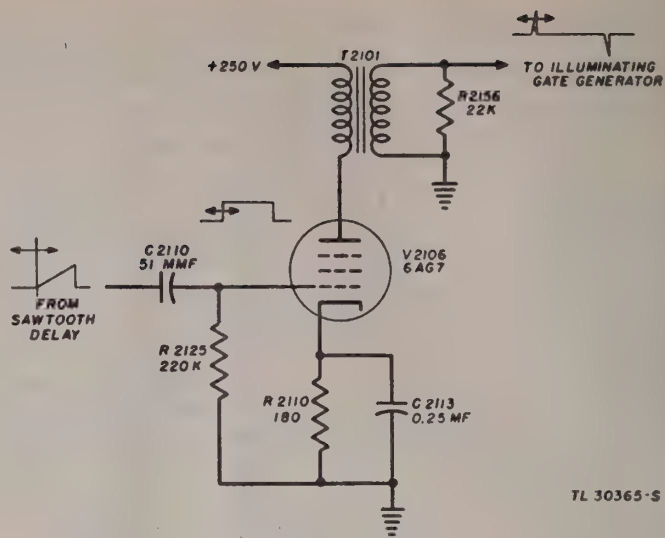

Figure 121. Differentiator and amplifier.

initial jump is added to the waveform. Figure 120 (A) shows the action of the generator without the bootstrap action. As soon as the tube 2112A is cut off, capacitor C starts charging exponentially, at a rate determined by the time constant of the circuit. The output of the stage is the combined voltage drop across C and R. The bootstrap cathode follower V2112B causes the supply voltage of the capacitor charging circuit to increase as the charge on capacitor C increases. This increasing supply voltage keeps the current through the R-C circuit constant producing the more linear waveforms shown in figure 120 (B).

(*3*) The bootstrap cathode follower V2112B operates between the –105-volt supply and the +250-volt supply in order that the stage may operate linearly even when the voltage across capacitor C2101 and resistor R2116 is very low. The initial voltage drop across the bootstrap feed-back capacitor C2108 is nearly equal to the B+ supply voltage. As the cathode potential of V2112B rises, the cathode voltage of V2101A will also rise. The diode stops conducting and allows the cathode voltage to rise well above B+ without loading the feed-back circuit. With this arrangement, the supply voltage for the trapezoidal voltage generator is nearly +250 volts greater than the output voltage as long as capacitor C2108 holds its charge. Since C2101 is so much smaller than C2108, at the end of the cycle when C2101 has charged to a rather high voltage, the voltage across capacitor C2108 will have changed very little.

b. Pick-off Diode. The pick-off diode V2101B provides the voltage controlled delay action of the stage. The control voltage is applied as a positive bias to the cathode of the pick-off diode. In the normal state, this diode cannot conduct, for its cathode potential is higher than the plate potential. Until the plate voltage is driven more positive than the cathode, no current flows through the diode, and the voltage across the diode load resistor R2125 is zero. When the trapezoidal voltage overcomes the cathode voltage on the diode, the diode conducts and the delay saw tooth appears across the diode load resistor. For low values of control voltage, the start of the saw-tooth voltage appears sooner than for high values of control voltage. It is the leading edge of the saw-tooth voltage that provides the trigger to the remaining circuits in the automatic range tracking unit.

114. DIFFERENTIATOR AND AMPLIFIER (fig. 121).

a. Differentiator. The saw-tooth output from the pick-off diode load resistor is differentiated in the coupling circuit R2125 and C2110 between the saw-tooth delay circuit and the amplifier. The result of this differentiation is a rectangular pulse. It is developed as follows: Capacitor C2110 and resistor R2125 form a short time constant circuit; so the voltage across the capacitor follows the input voltage very closely. With a saw-tooth voltage input, the capacitor voltage is a saw-tooth voltage. When a saw-tooth voltage is applied to a capacitor, a constant charging current flows to that capacitor. This constant charging current flowing to capacitor C2110 through resistor R2125 produces a constant rectangular voltage pulse that lasts for the duration of the saw-tooth wave.

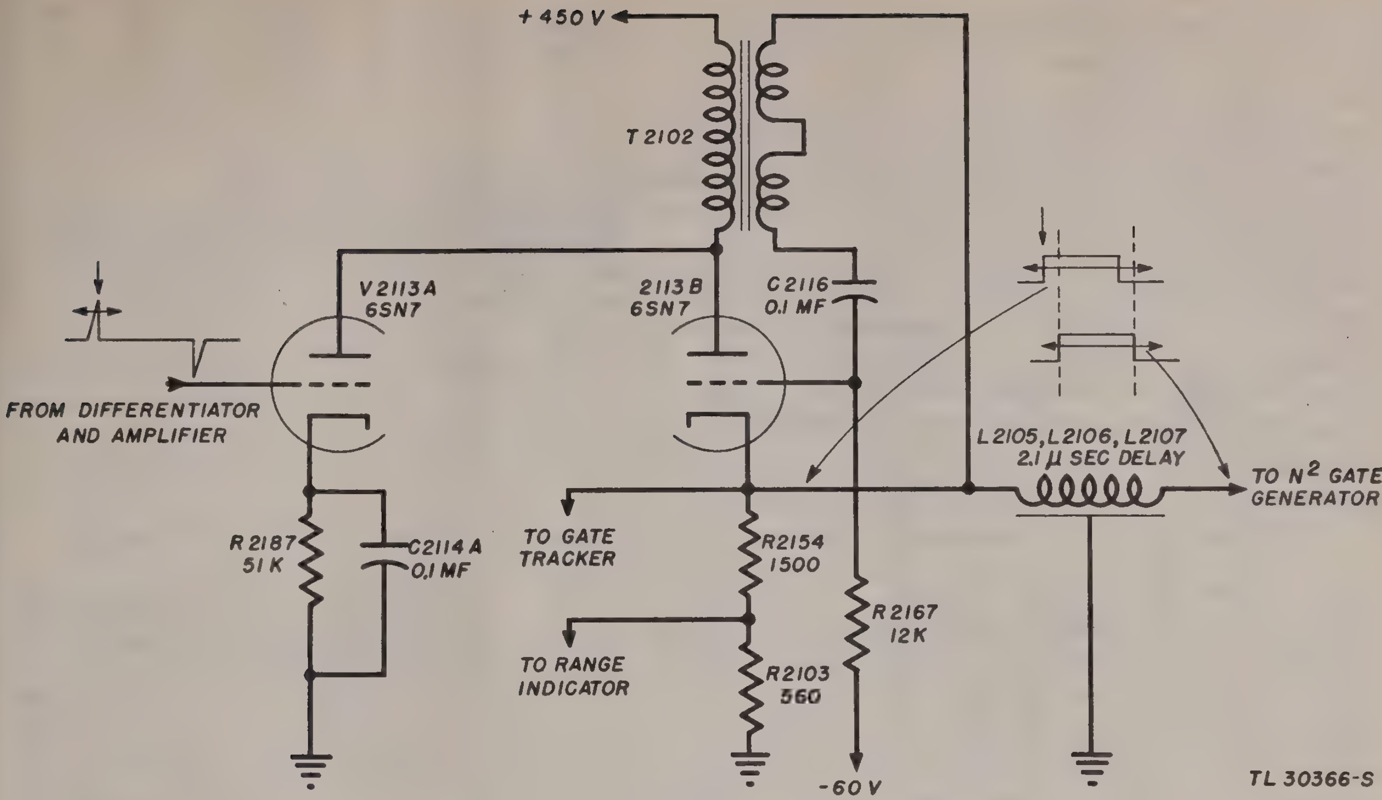

Figure 122. Illuminating gate generator.

b. Amplifier. The rectangular pulse is amplified and pipped in the rest of the stage. Tube V2106 is normally conducting moderately, the bias developed across the cathode resistor R2110 limits the plate current of the tube. When the positive pulse is applied to the grid through the differentiator, the plate current through the transformer T2101 increases. This changing current induces a positive voltage pip in the secondary windings. No voltage is induced in the secondary windings for the remainder of the rectangular input pulse because the tube current does not change until the trailing edge of the pulse arrives and the tube is restored to the normal state. The decrease in plate current generates a negative pip in the secondary winding. The input of this stage V2106 is a saw-tooth wave of variable duration set by the control voltage, and the output is a positive pip occurring at a time set by the control voltage and a negative pip occurring at 45,000 yards range. The positive pip is used to control the illuminating gate generator.

115. ILLUMINATING GATE GENERATOR.

The illuminating gate generator (fig. 122) is composed of two stages, the driver stage V2113A and the blocking oscillator stage V2113B. The cathode resistor in the driver stage is large. This puts a large negative bias on the grid of that stage, making the driver well suited to amplify the positive trigger from the differentiator and amplifier. This large bias also helps to reduce any effects of the negative trigger that trails the positive one. The blocking oscillator is a single swing blocking oscillator and is held well beyond cut-off by the large fixed bias on the grid. When the positive trigger from the differentiator and amplifier is applied to the grid of the driver tube, the current through the blocking oscillator transformer T2102 is increased. This induces a voltage in the secondary winding that is applied to the grid of the tube as a positive voltage. The grid of the oscillator tube is thus driven sufficiently positive to overcome the fixed bias on the tube and the oscillator tube draws current. This increase in current through the transformer primary drives the oscillator grid further positive, increasing the grid voltage and the plate current until current saturation is reached in the tube. When the primary current of the oscillator plate transformer stops increasing, the secondary induced voltage no longer appears on the grid, and the grid voltage drops. This decreasing grid voltage decreases the plate current and causes a voltage to be induced in the grid winding that further reduces the grid voltage and cuts off the oscillator tube. Once the oscillator tube is cut off, it is held in

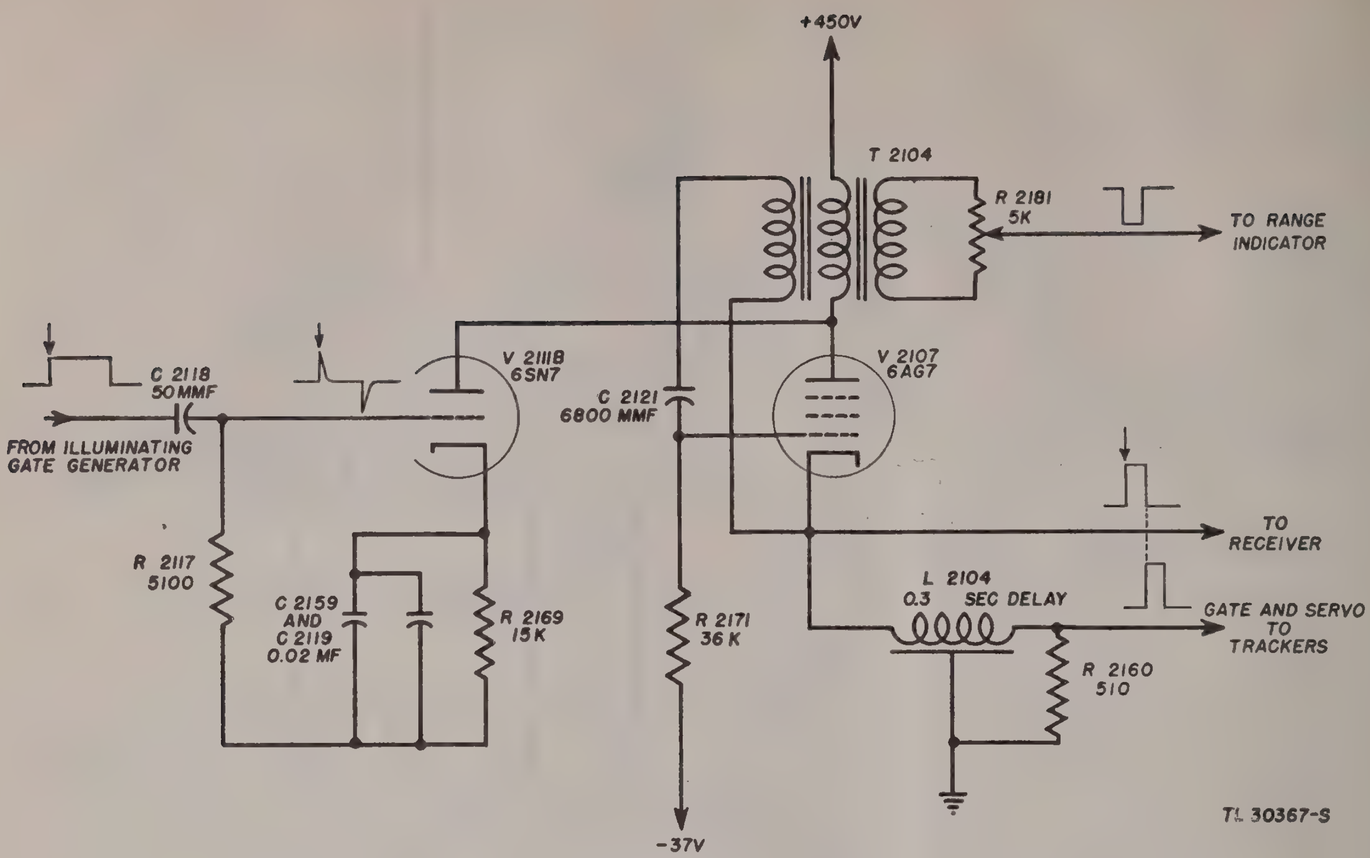

Figure 123. N² gate generator.

the non-conducting state by the fixed bias until the driver tube starts a new oscillation. The constants of the circuit are such that the output of this tube is a 10.8-microsecond pulse. This gate is used to illuminate 1,800 yards of the fine range scope, to hold the gate tracker inoperative except during the time that the selected echo is expected to appear, and when delayed and differentiated, to trigger the N² gate generator.

116. N² GATE GENERATOR.

The N² gate generator (fig. 123) like the illuminating gate generator, is made up of two stages, the driver stage and the oscillator stage. The output of the illuminating gate generator is passed through a 2.1-microsecond delay line L2105 (fig. 122) and the delayed pulse is differentiated by C2118 and R2117 producing a positive and a negative pip. The positive pip is used to start the N² gate generator in a manner identical to the starting of the illuminating gate generator (par. 115). A pentode V2107 is used in this circuit to provide a larger gate output than could be obtained with a triode. This circuit provides a 0.3-microsecond positive-going voltage pulse that is used to operate the gated channel in the receiver, and to operate the trackers. The 0.3-microsecond delay line L2104 is used to delay the signal to the trackers to compensate for the delay in the receiver cable and insure that the trackers and the receiver operate at the same instant. A negative-going 0.3-microsecond pulse is taken from the third winding of transformer T2104 and applied to the cathodes of the range scopes to indicate the time that the servo channel of the receiver is turned down.

117. VIDEO PEAKER (fig. 124).

The input circuit of the video peaker is an L-C peaker. Resistor R2157 is a current limiting resistor which limits the grid current between video signals. When the negative video signal is applied to the L-C peaker, the grid voltage drops suddenly at first, for the voltage across the capacitor cannot change instantaneously. The capacitor rapidly charges up through the inductance, and the grid voltage drops to zero. When the trailing edge of the negative video pulse comes along, the grid tends to go positive, but grid current limits the rise in grid voltage; so the positive pip is lost. This peaker changes the width of the video signal from over 1 microsecond to approximately 0.3 microsecond. The compensating coil in the L2102 in the plate circircuit of peaker V2108 helps preserve the steepness of the peaked video signal.

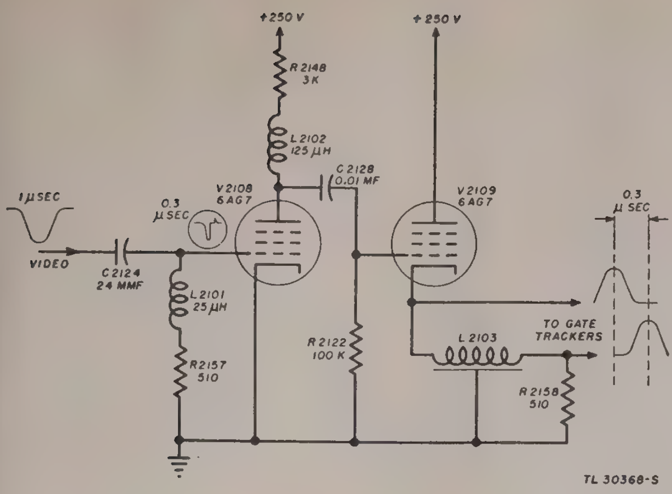

Figure 124. Video peaker and splitter.

118. VIDEO SPLITTER (fig. 124).

The output of the video peaker is applied to the grid of the video splitter tube V2109. This tube (fig. 124) is connected as a cathode follower with a delay line as the load in the cathode circuit. One output is taken from the input end of the delay line, and the other from the load end of the line. This provides two peaked video signals separated by 0.3 microsecond. The width of the signals and the separation is such that the trailing edge half power point of the first pulse coincides with the leading edge half power point of the delayed pulse. This is the point on which the N^2 gate tracks.

119. N^2 GATE TRACKER (fig. 125).

The N^2 gate tracker stage (fig. 125) operates with the split video signal input to the grids, and the N^2 gate signal to the plates during automatic range tracking operation. During manual operation, a push-pull 410-kc sine wave signal is applied to the grids instead of the split video signal. As the signals on the grids shift in time with respect to the N^2 gate signal, the output of the tracker causes the gate time to change to coincide with the new time of the grid signal. The shift of time of the video signal is caused by a change in the range of the target. The change in time of the sine wave is caused by the phase shift introduced by turning the range handwheels.

a. Track Video. Tubes V2102 and V2103 (fig. 125) are both held in a nonconducting state by connecting them across a voltage divider made up of V2114B, R2174, and R2175 (fig. 128) in such a manner that the plates of the tubes are made more negative than the cathodes. The N^2 gate is applied to the plates of both the tracker tubes, and the first pulse of the split video signal is applied to the grid of tube V2103 while the second pulse of the split video signal is applied to the grid of tube V2102. When both the plate and grid signals are applied to tube V2102, plate current flows through that tube, charging capacitor C (by removing electrons

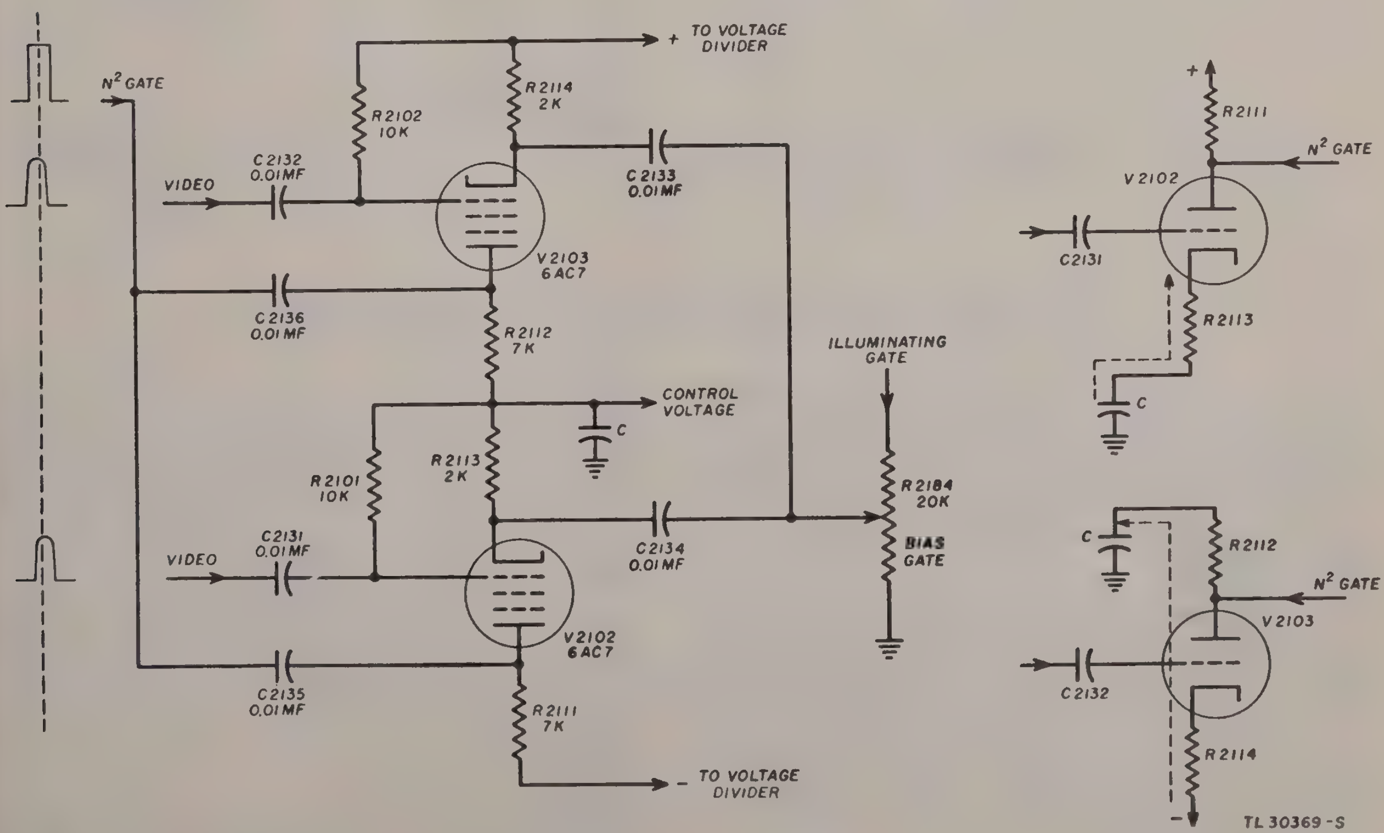

Figure 125. Gate tracker.

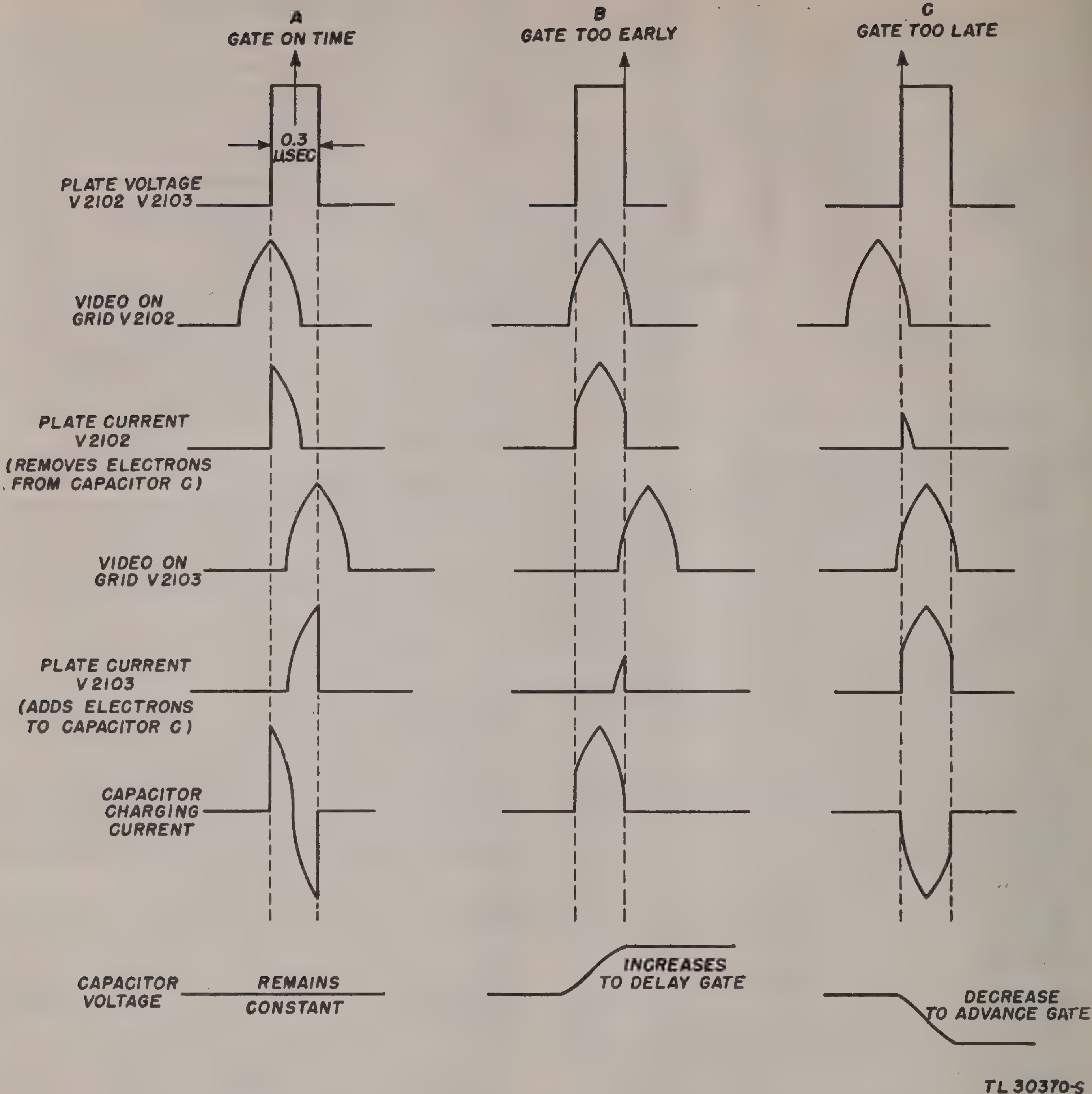

Figure 126. Gate tracker waveforms, automatic range tracking.

from the ungrounded plate) and thus raisng the control voltage. When the plate and grid signals are applied to tube V2103, that tube plate current discharges capacitor C (by adding electrons to the ungrounded plate) lowering the control voltage.

(*1*) When the time relationship between the gate and the split video signals are such as shown in figure 126A, tube V2102 removes as many electrons from the capacitor as are added to the capacitor by tube V2103; so the net capacitor voltage does not change. This is the *on-target range position.*

(*2*) When the gate range is less than the video signal range as shown in figure 126(B), tube V2102 conducts more electrons from the capacitor than are added to the capacitor by tube V2103; so the control voltage is increased to increase the delay time and restore the N^2 gate to the on-target range position.

(*3*) The action of the circuit when the gate arrives too late is shown in figure 126(C). In this case the capacitor voltage is decreased to decrease the delay and restore the gate to the on-target range position.

b. Tracking Sine Waves. The operation of the tracker is the same during manual ART operation as during automatic range tracking opera-

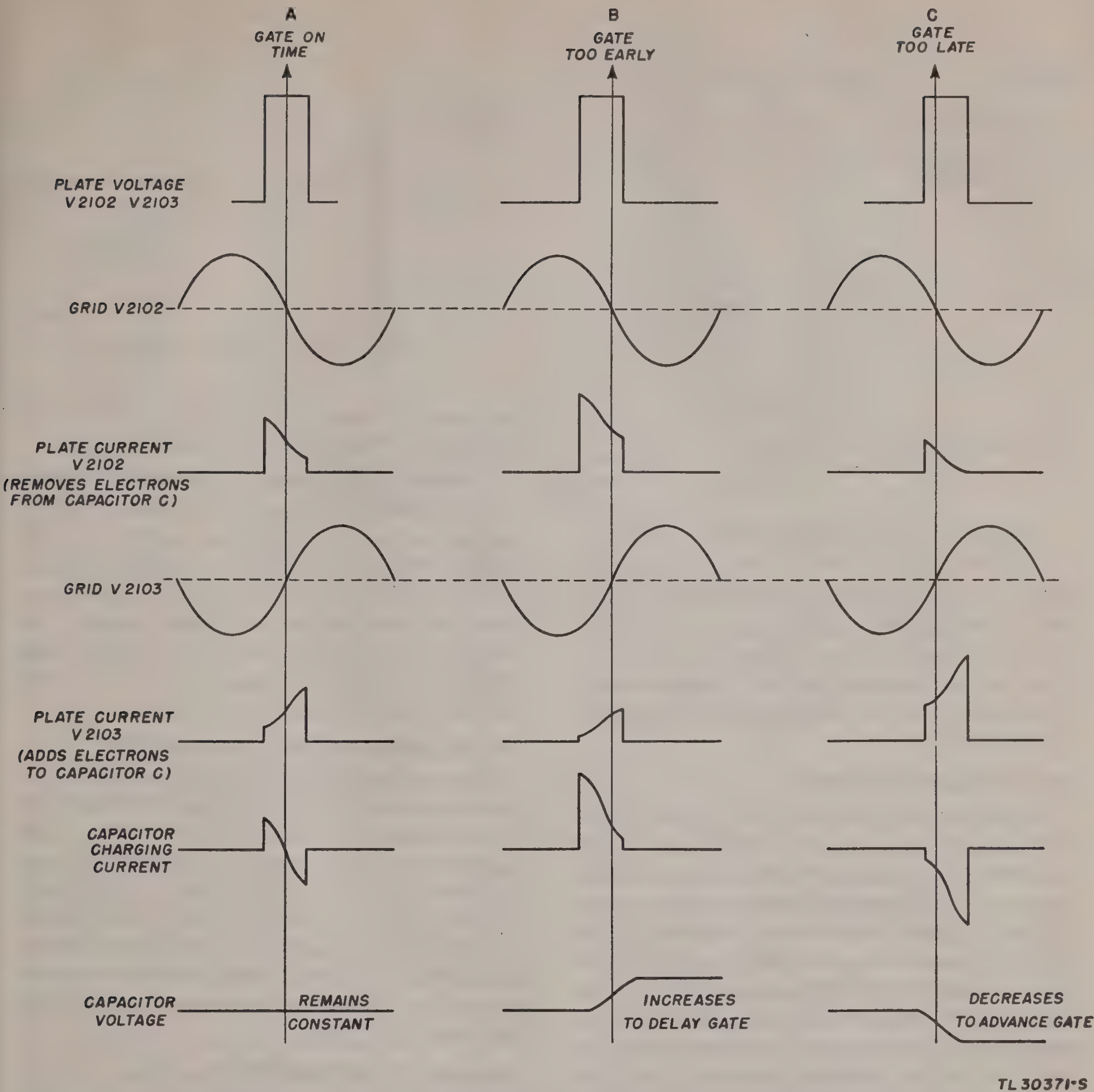

Figure 127. Gate tracker waveforms, sine wave (manual) tracking.

tion, except that instead of two video signals, a sine wave is applied to each grid of the tracker tubes. The waveforms in the circuit during manual operation are shown in figure 127.

c. Voltage Divider Action. The voltage divider made up of bias tube V2114B and resistors R2174 and R2175 is shown in the simplified schematic diagram, figure 128. As the control voltage output of the storage network, represented by capacitor C in figure 128 increases, the grid voltage of tube V2114B is increased. This raises the voltage at the cathode of that tube and also at the junction of the two resistors R2174 and R2175. This causes all the d-c operating voltage in the tracker to increase by nearly the same amount that the control voltage increases. By doing this, both tracker tubes are operating at nearly the same optimum point on their characteristics regardless of the level on the control voltage, thus affording a wider range of operation of these tubes.

d. Bias. The illuminating gate is applied to the cathodes of the tracker tubes before the N^2 gate is applied to the plates and remains on the cathodes until after the N^2 gate is removed from the plates. This negative bias prevents the tracker tubes from being operated by noise on the grids. By adjusting the BIAS GATE control

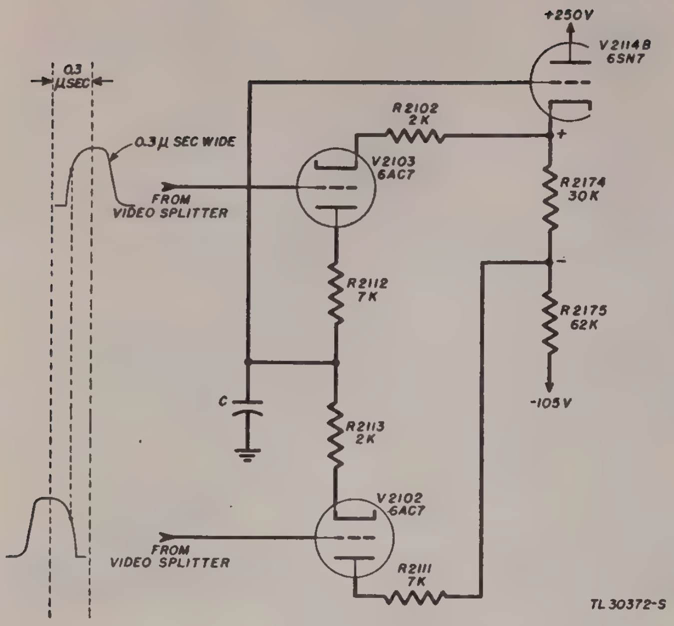

Figure 128. Gate tracker voltage divider.

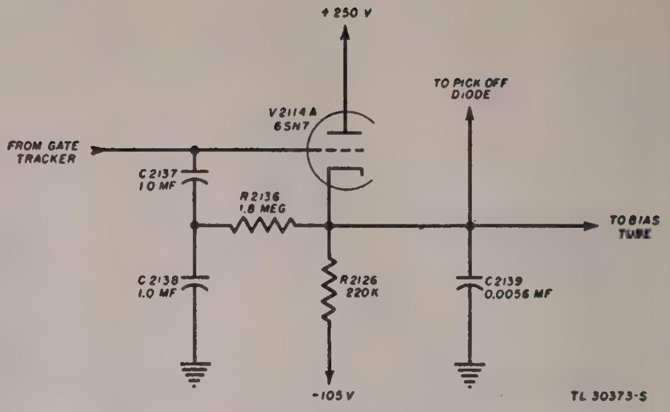

Figure 129. Storage network.

R2184, the voltage between the grids and cathodes of the tracking tubes can be made such that the tubes will not operate on the video noise, but the video signals will be large enough to overcome the bias and operate the circuit as discussed above.

120. STORAGE NETWORK.

The capacitor represented as C in the preceding paragraph (fig. 125) is, in the actual circuit (fig. 129), the storage network made up of series capacitors C2137 and C2138 and the cathode follower V2114A with its load capacitor C2139. The series capacitors are charged by the tracker tubes. Because they are connected in series, the time constant of the charging circuit is small. Resistor R2136 connected from the cathode of the tube to the common point of the series capacitors provides feedback to aid in charging or discharging one of the input series, capacitor C2137. The output of the storage circuit is taken across capacitor C2139. Any charge taken from this capacitor by the circuits controlled by the control voltage is replaced by the cathode follower tube V2114A; so the voltage across that capacitor remains at the level determined by the charge on the input capacitors. The input capacitors have no load on them; so they retain their charge unless it is changed by the trackers. The storage network thus has two features that could not be gained by using capacitors alone; it has a short time constant as far as the tracker tubes are affected, and presents a long time constant to the output circuit. This means that the storage network responds rapidly to changes impressed by the tracker tubes, yet will be unaffected by effects of the controlled circuits.

121. OSCILLATOR GATE CATHODE FOLLOWER.

The oscillator gate cathode follower V2111A (fig. 143) is located in the automatic range tracking unit. It is a conventional cathode follower and is used to isolate the input multivibrator from the low impedance cable between the automatic range tracking unit and the range indicator where the circuits of the 410-kc oscillator phase shifter are located.

122. OSCILLATOR GATE AMPLIFIERS.

The gate amplifier V951A (fig. 142) located in the range indicator unit is a triode amplifier used to step up the amplitude of the low-voltage gate signal received from the cable between the range indicator and the automatic range tracking unit. The output of this stage is a negative square wave that starts at the same instant that the transmitter is started, and remains negative for the first 45,000 yards range time following the transmitted pulse.

123. 410-KC OSCILLATOR (fig. 130).

The shock-excited oscillator (fig. 130) is used to provide a source of alternating voltage that can be kept in step with the main transmitter pulse. The oscillator is shocked with a pulse so timed that the oscillator starts on a negative half-cycle each time the magnetron is turned on. The shock-excited oscillator stage is made up of tubes V951B and V952A. Tube V951B, in the absence of the negative gate signal from the amplifier stage V951A, is conducting normally. The current drawn by the tube flows through the coil in its cathode circuit, building up a magnetic field around the coil. When tube V951B is cut off by the negative gate from the amplifier, the tube current suddenly stops flowing. The initial electron flow through the inductance cannot stop immediately; so capacitor

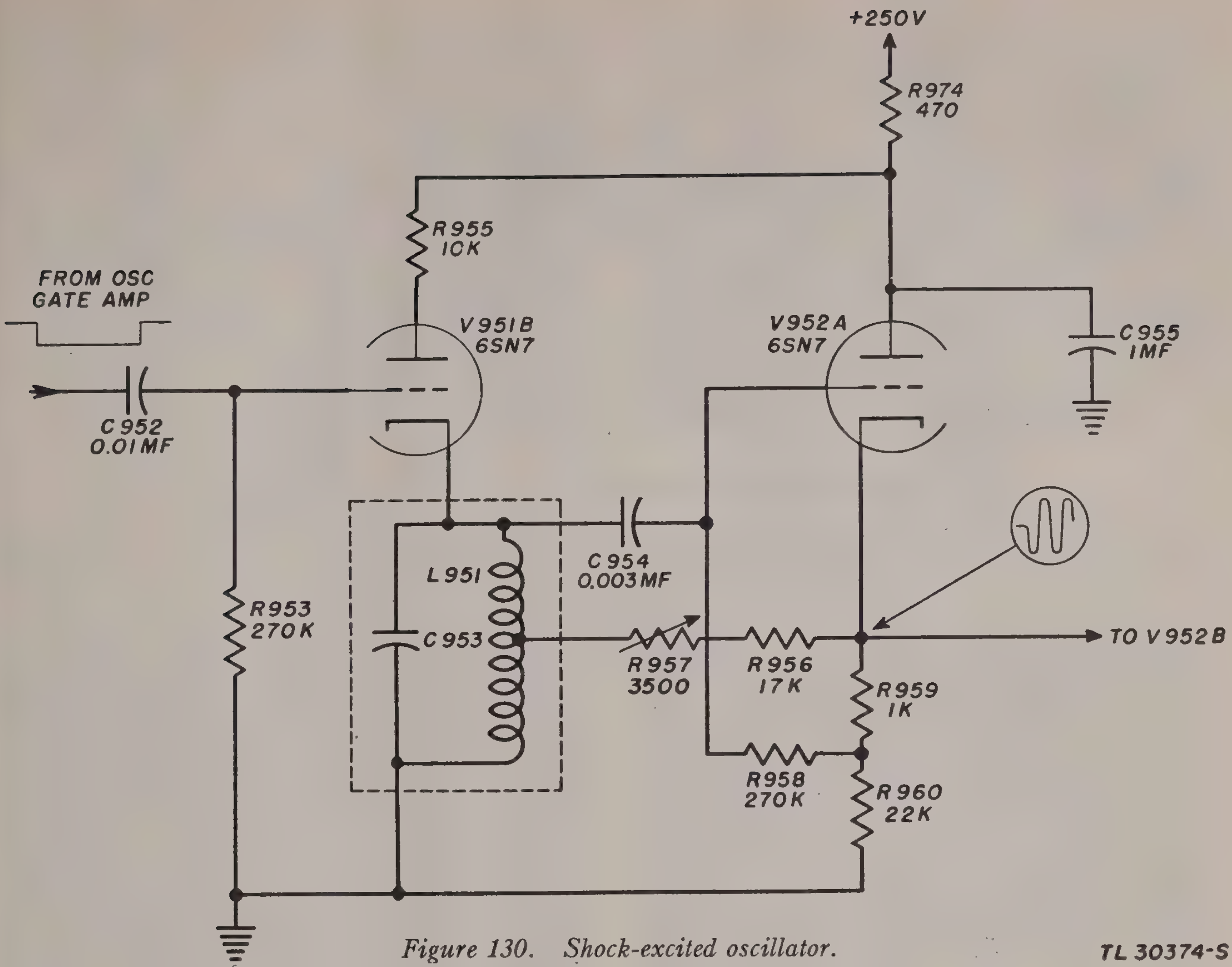

Figure 130. Shock-excited oscillator.

C953 becomes charged with electrons, causing a negative voltage to appear across the capacitor. When the current flow through the tube stops, the capacitor discharges through the coil, setting up a current in the opposite direction. This exchange of energy from the magnetic field around the coil to an electric field in the capacitor continues at a rate determined by the constants of the oscillatory circuit L951 and C953. Tube V952A is connected to the coil as a Hartley type oscillator and serves to maintain the oscillations in the oscillatory circuit. The amount of degeneration in the oscillator stage is controlled by variable resistor R957, the ENVELOPE control. This control should be set so that the amplitude of the oscillations remains constant throughout the whole oscillation period. If there is too little resistance in the cathode feedback circuit, the oscillations increase in amplitude; too much resistance causes the amplitude to decrease.

124. PHASE SHIFTER DRIVER.

Tube V952B (fig. 131) is connected as a cathode follower to isolate the oscillator from the phase shifter and provide the low impedance source of power for the phase shifter. Resistor R962 and capacitor C956 are used to supply the bias for the stage. The resistance of the transformer is too low to provide sufficient bias.

125. PHASE SHIFTER.

Transformer T951 (fig. 131) in the cathode circuit of V952B has one primary winding and two secondary windings. In this circuit application, the two secondary windings are connected in series. Instead of grounding the common point of the two windings to obtain the 180-degree phase shift between outputs of the transformer, resistors R963, R964, and R965 are connected in series across the secondary windings, and the electrical midpoint is grounded through the variable tap on resistor R964. This insures that the two voltages are exactly equal. Capacitor C957 connected from one secondary winding

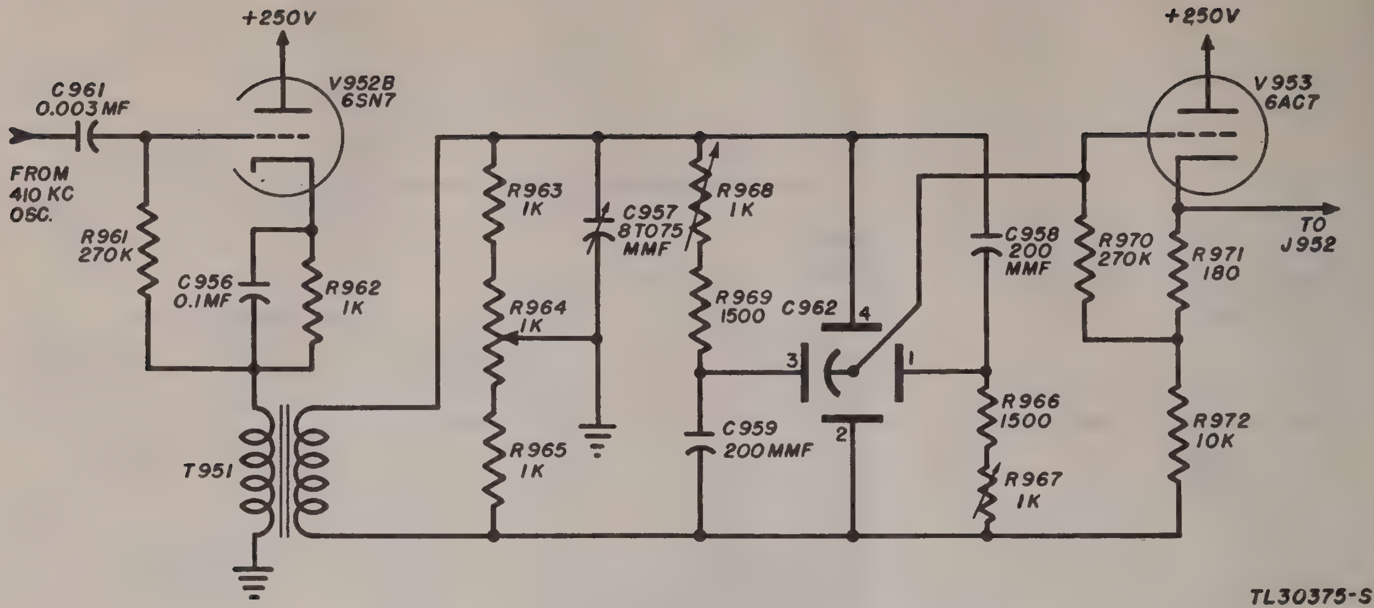

Figure 131. Phase shifter, driver, and amplifier.

terminal to ground is used to equalize the capacity to ground of the two secondary windings and thus insure that the two secondary voltages are exactly 180 degrees out-of-phase. The external capacitor is required because the transformer is layer-wound and one secondary, being closer to the grounded core than the other, will have more stray capacitance to ground. These voltages are applied to plates 2 and 4 of the phase shifter capacitor. The arrows 2 and 4 in figure 132 represent these voltages, and G, the common point is ground. Capacitors C958 and C959 have a reactance of approximately 2,000 ohms at 410 kc. Resistors R966 and R967 are adjusted to have a total resistance equal to the reactance of capacitor C958, and

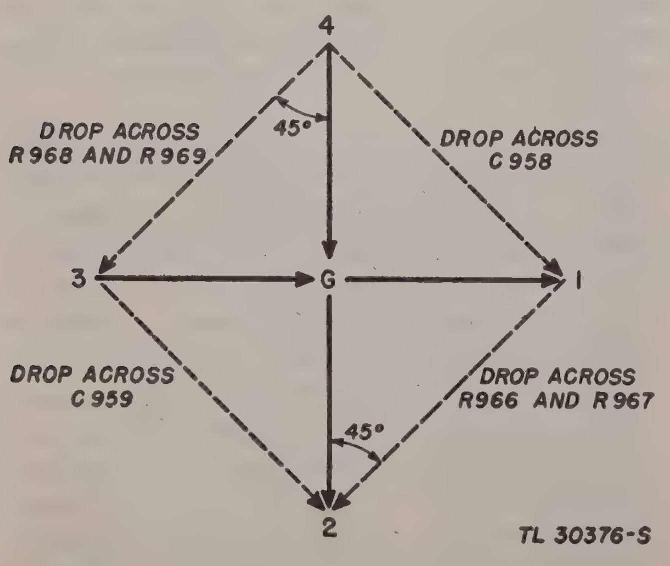

Figure 132. Phase shifter capacitor, input voltage vectors.

resistors R968 and R969 are adjusted to have a total resistance equal to the reactance of C959. The currents will lead the voltage applied to these circuits by 45 degrees in this balanced condition. These circuits are connected across terminals 2 and 4 of the capacitor. The voltage drops across the series combination R966, R967, and capacitor C958 are shown by the right arrows in figure 132, while the drops in the other divider network are shown by the left arrows. The voltage drops across the capacitors lead the current by 90 degrees, and the drop across the resistors are in phase with the current. The arrows between G1 and G3 represent the voltage applied to plates 1 and 3 by the divider networks. From the arrows 1, 2, 3, and 4 it can be seen that the voltages applied to the phase shifter capacitor C962 are all equal and 90 degrees out-of-phase with one another. The construction of the capacitor is shown in figure 133. Each of the voltages 1, 2, 3, and 4 are applied to one of the segments of the divided plate. The output is taken from the solid plate of the capacitor. The dielectric disk between the two plates of the capacitor increases the capacity between the plates adjacent to it by about 8 times. The manner that the phase shift is developed is illustrated in figure 134. The construction of the dielectric disk is such that the phase shift is exactly proportional to the rotation of the capacitor shaft. As shown in figure 134 when the shaft is on the zero degree position (with the slot on the end of the shaft aligned with the slot in the bearing housing and the bevel on the shaft end near terminal 1) the output signal

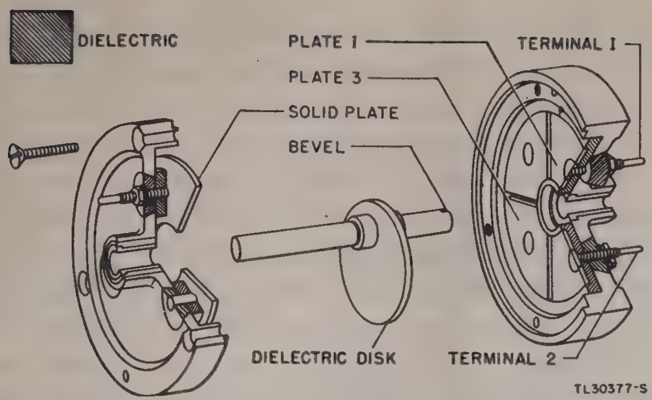

Figure 133. Phase shifter capacitor, construction details.

is in phase with the signal on plate 3. Turning the capacitor shaft 45 degrees clockwise as viewed from the rear of the range unit (clockwise rotation of the handwheel) causes the dielectric disk to be turned to give more pick-up from plate 4 and less from plate 3, causing the phase of the output signal to be delayed by 45 degrees. The change of phase with position of the dielectric disk can be seen from figure 134 by adding the sine wave components of the voltage coupled to the pick-up plate through the disk.

126. PHASE SHIFTER CATHODE FOLLOWER.

Tube V953, connected as a cathode follower, is used to provide a very high impedance circuit for the phase shifting capacitor to work into. Distortion of the linear phase shift caused by loading the capacitor output plate is prevented by not loading the capacitor. The cathode follower also supplies the low impedance source for the cable coupling the signal from the range indicator unit to the automatic range tracking unit. By returning the grid to the junction of the two cathode resistors R971 and R972 instead of to ground, the bias on the tube during the period between oscillations of the shock-excited oscillator is held at the optimum value for linear operation of the cathode follower.

127. SINE WAVE AMPLIFIERS.

Tubes V2104 and V2105 (fig. 143) located in the automatic range tracking unit amplify the sine wave signal from the phase shifter cathode follower and provide the push-pull output for operating the tracker stages. The first stage V2104 is a conventional pentode amplifier with the cathode resistor left unbypassed to provide a small amount of degeneration and make the amplifier more stable. The second stage V2105 has a transformer load instead of the resistor load in the other stage. The transformer used is the same type as used in the phase shifter driver stage. The output is balanced in amplitude by resistor R2183 and in phase by capacitors C2117 and C2164.

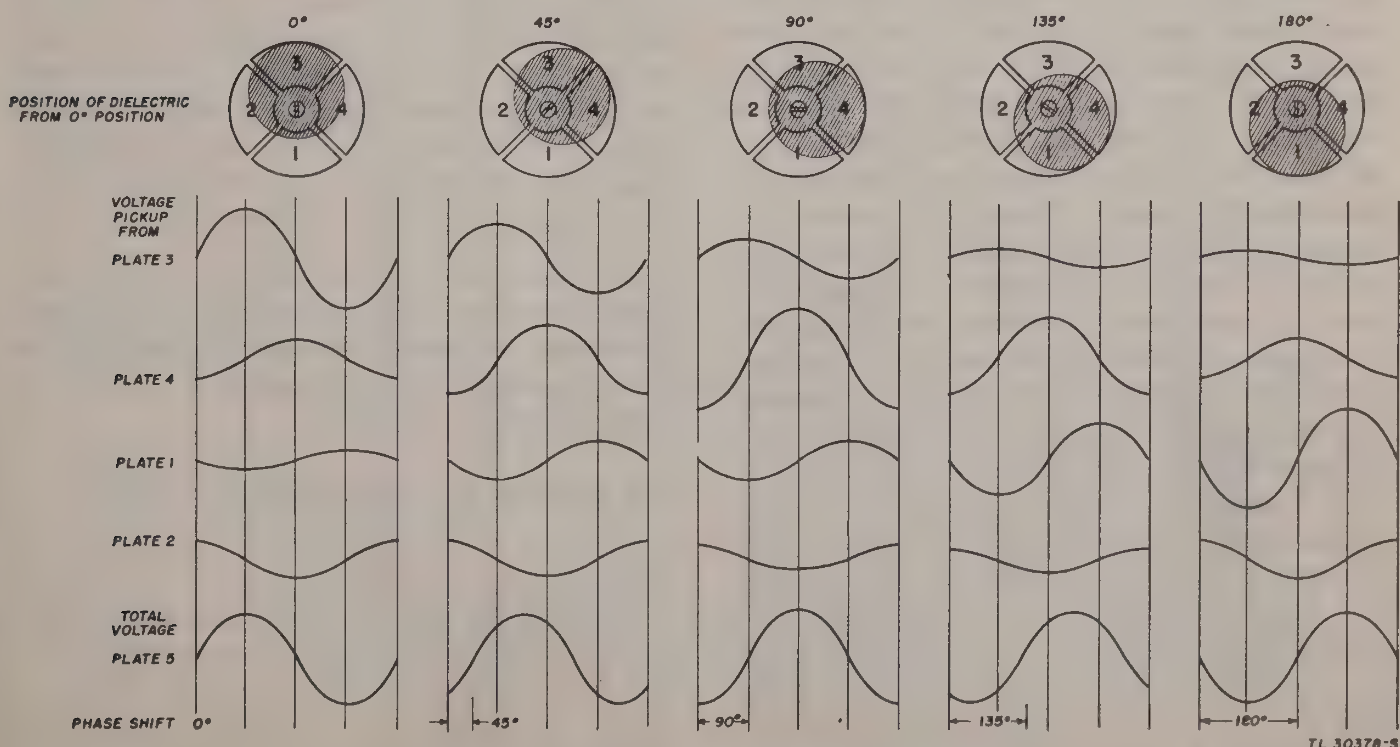

Figure 134. Phase shifter capacitor, waveforms.

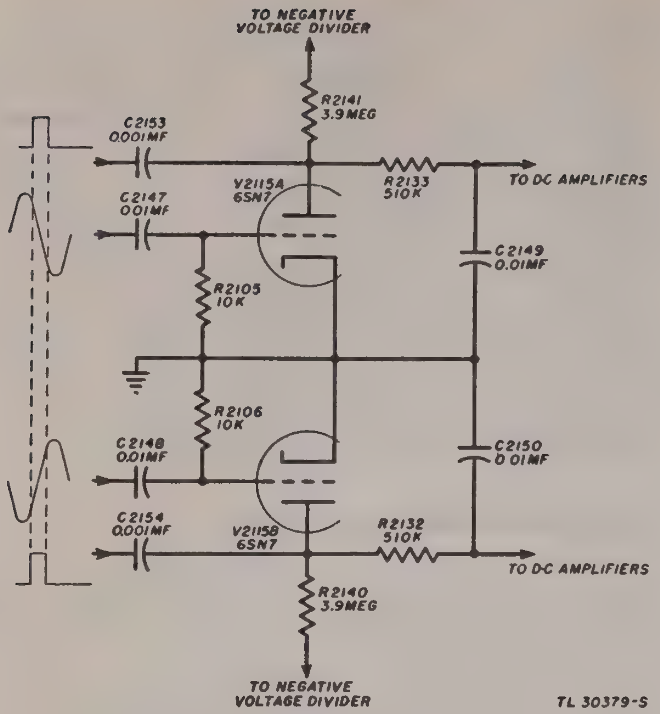

Figure 135. Servo tracker.

128. SERVO TRACKER.

The servo tracker is shown in figure 135. Tubes V2115A and V2115B are held in a nonconducting state by applying –6 volts to their plates through the 3.9-megohm load resistors R2140 and R2141. The N^2 gate is applied as a positive voltage to both plates simultaneously, and the output of the push-pull sine-wave amplifier stage is applied to the grids. The tracking motor speed depends upon the d-c voltage across the capacitors C2149 and C2150. When the time relationship between the gate and the sine wave is as shown in figure 136(A), range hairline over the gate, the average voltage across the capacitors does not change. Figure 136C shows the change in the average capacitor voltage when the range motors have allowed the range indicated by the hairline to become greater than the gate range. In this case the average d-c voltage on the plates of the tracker tubes is changed. The potential of the plate of V2115A is lowered, and the voltage at the plate of V2115B is raised. This change of potential causes the voltage across C2149 to decrease and that across C2150 to increase from the hairline on gate position due to the change in tube resistances. This change of potential is amplified and causes the d-c level at the grid of thyratron rectifier tube V927 in the range indicator unit to increase while the level at the grid of tube V928 is decreased. This causes the component of current through the drive motors, that tends to turn the motors in the direction of decreasing range, to increase and thus restore the proper time relationship between the gate and the range hairlines by shifting the phase of the sine wave output of the oscillator phase shifter. Figure 136(B) shows the voltages and currents when the hairline range is less than the gate range and the drive motors must turn more in the direction of increasing range. In this case, the voltage at the plate of V2115A is increased, while the voltage at the plate of V2115B is decreased; then these changes are amplified and the d-c voltage level at the grid of thyratron tube V927 is decreased, causing that tube to conduct less and thus increase the range reading of the hairline.

129. FIRST D-C AMPLIFIER (fig. 137).

The first d-c amplifier stage (fig. 137) is made up of tube V2116A and B and has coasting capacitors in the grid circuits.

a. The output of the servo tracker is applied to the d-c amplifier through the coasting circuit. This coasting circuit is merely a capacitor with a series resistor (C2155, C2156, and R2173 for V2116A, and C2161, C2162, and R2104 for V2116B). The capacitors hold the voltage level at the grids of the d-c amplifier; so when a target is being tracked and there is danger of interference from another, the coast button may be pressed, and the voltages in the servo tracker channel remain unchanged causing the range drive system to coast along at its original rate and pass the interfering signal. Resistors R2173 and R2104 are placed in series with the coasting capacitors to make the system sensitive to relatively rapid changes in target range.

b. The amplifiers are cathode followers connected between –105 volts and +250 volts. Returning the cathode loads to –105 volts rather than to ground makes the amplifier more sensitive at low input voltages.

130. SECOND D-C AMPLIFIER (fig. 137).

The second d-c amplifier (fig. 137) is a conventional, direct-coupled, push-pull amplifier. It is connected between the –105 volt supply and the +250 volt supply to make the operation more linear at low values of input. Resistors R2130 and R2131 with capacitors C2151 and C2152 form filters to smooth the d-c input to the amplifiers. The output circuit is connected

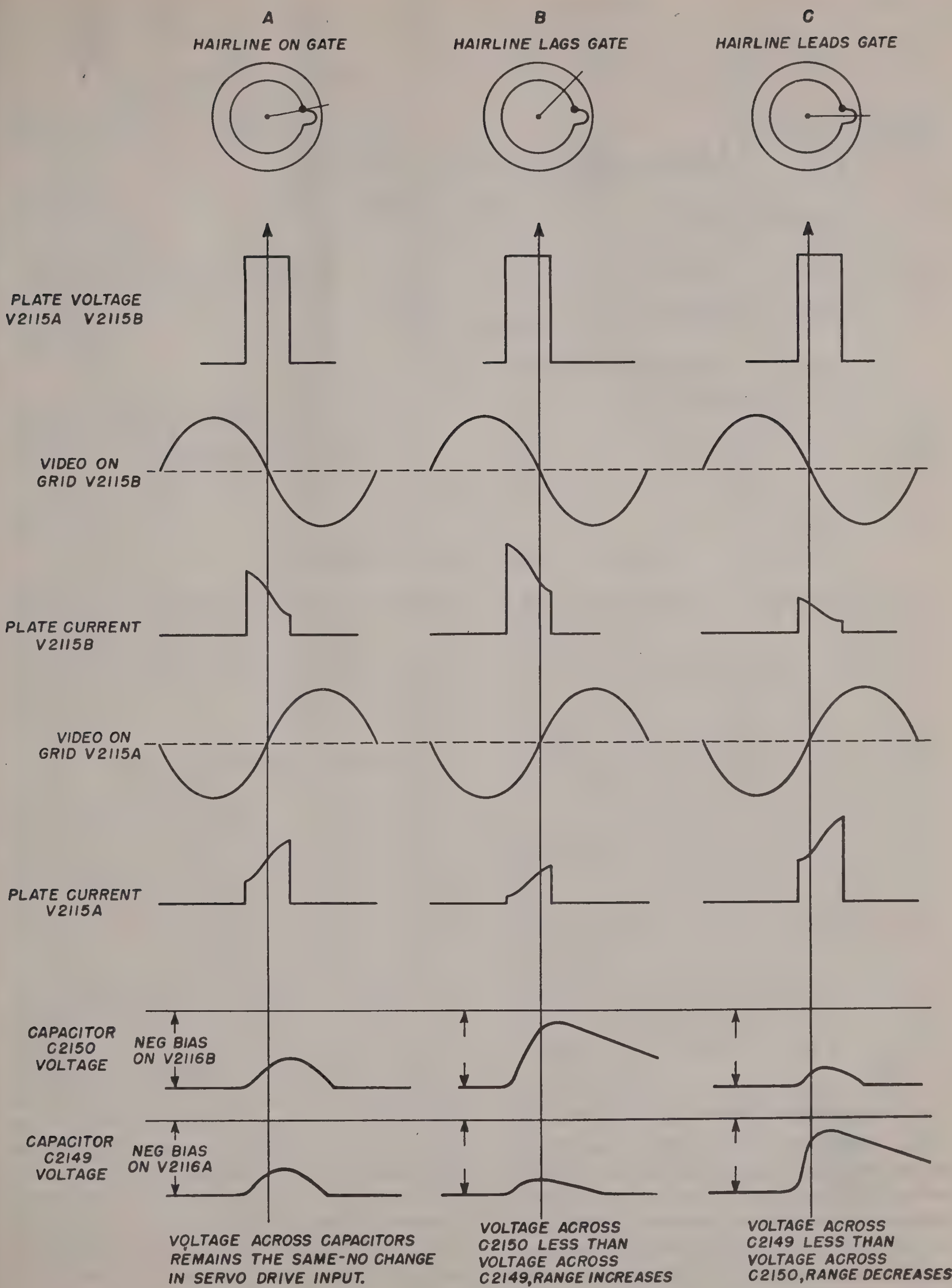

Figure 136. Servo tracker waveforms.

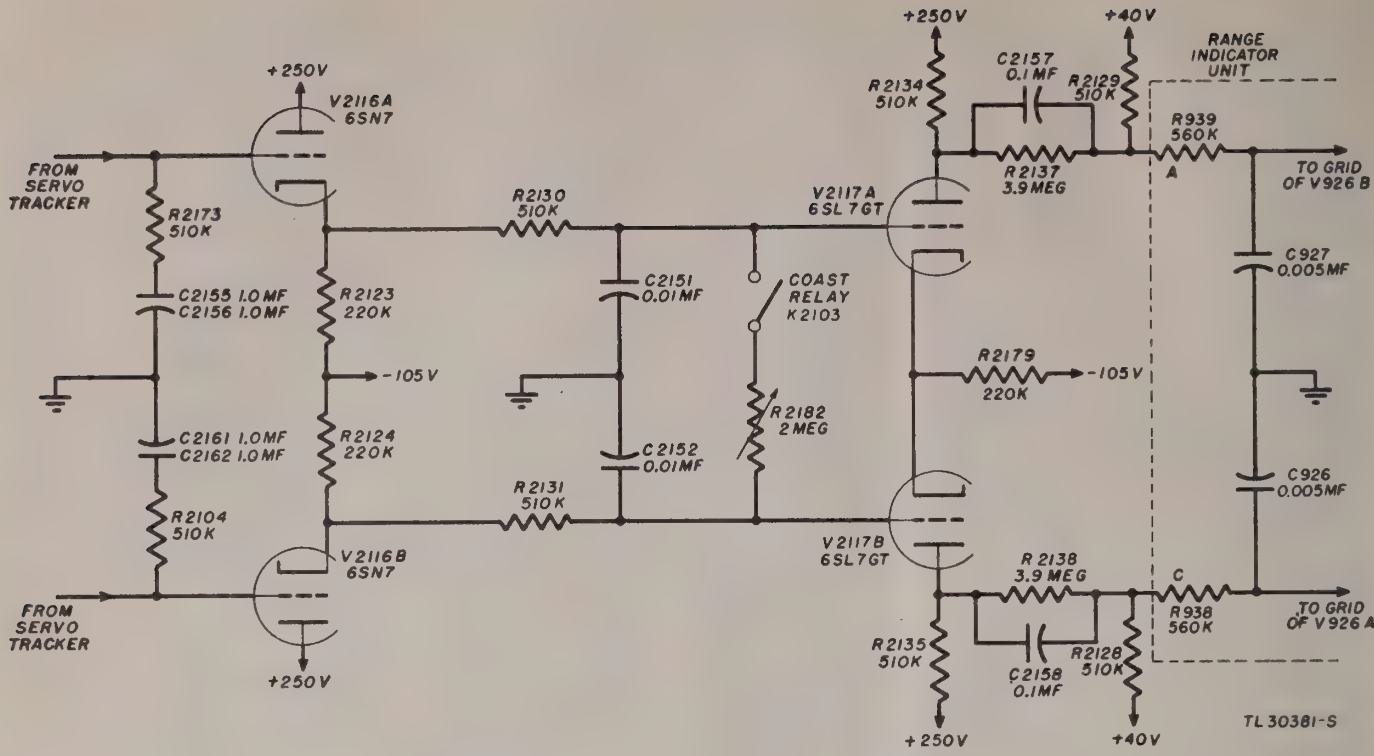

Figure 137. First and second d-c amplifiers.

to a + 40-volt point on a voltage divider which is used to raise the level of the output to the value required by the d-c amplifier in the range servo drive circuit. To couple the output voltage from the plates of the amplifier tubes to this lower reference voltage, both direct and capacitor coupling is used. The capacitor coupling couples the rapid changes to the grids, while the 4-megohm resistors couple the d-c signals to the grids, allowing the d-c level to be changed and remain changed without the charging and discharging of the capacitor affecting the average voltage. The COAST potentiometer R2182 connected between the grids of the second amplifiers reduces the gain of those amplifiers during the coast time. It has been found that the servo system speeds up during the coast operation; so to hold it down to the correct speed, the resistor is used to reduce the gain of the one stage in the coasting circuit.

131. RANGE SERVO DRIVE CIRCUITS (fig. 113).

The range servo drive circuits used during automatic range tracking are those in the range indicator discussed in paragraph 110, the only change being that during automatic range tracking the feedback generator B902 is used as a motor to aid the range drive motor by connecting the armature of the generator in parallel with the motor through relay K901 (fig. 142). The feed-back action is not required during automatic operation because any irregularities in the tracking rate will be corrected by the servo tracker. Putting the two motors in parallel makes the range indicator gearing operate better at low tracking rates where the power of two motors overcomes irregularities in the load with less speed change than one.

132. CONTROL CIRCUITS (fig. 143).

Four relays in the automatic range tracking unit do all the necessary circuit switching to enable the range system to be operated with either automatic range tracking or with manual range tracking, to provide a means of calibrating the tracking circuits, and to provide a means for coasting past interfering targets.

a. Servo Relay. The servo relay K2101 is connected to select the input for the servo circuits in the range indicator unit. When this relay is de-energized (the range tracking switch on the control panel in the AUTOMATIC position) the output of the automatic range tracking unit is connected to the servo drive circuits for automatic range tracking. In the energized position (with the RANGE TRACKING switch in the MANUAL position) the contacts of this relay connect the output of the tracking rectifier in the range indicator to the servo circuits in the range indicator. Thus it can be seen that if the automatic range tracking unit were removed and NORMAL operation of the range servo circuits is desired, it is necessary to make the connections normally made by relay K2101.

b. Tracker Relay. The tracker relay K2102 controls the operation of gate tracker.

(*1*) When the RANGE TRACKING switch on the control panel is in the MANUAL position, this relay is de-energized, connecting the tracker input to the sine wave amplifier, removing the bias gate from the circuit, and changing the circuit to make it more adaptable to sine wave tracking. With the RANGE TRACKING switch on the control panel in the AUTOMATIC position, the relay is energized and the video signals are connected to the grids of the tracker tubes with the bias gate restored to the circuit.

(*2*) When the COAST button is pressed, during automatic range tracking, the tracker relay is de-energized, and the circuit is connected as for manual tracking. This makes the gate tracker follow the sine wave signals from the range indicator rather than the video signals. By adjusting the coast circuits so that the range gearing will coast at a uniform rate, the gate, which will be tracking the sine waves, will coast at the same uniform rate.

c. Coast Relay. The coast relay K2103 is operated by the COAST button on the control panel. When this button is depressed, the coast relay becomes energized and disconnects the output of the servo tracker from the d-c amplifier. In this case, the servo circuits continue to run at the rate determined by the voltage at the input circuits the time the relay was opened. The capacitors in the input stage hold the grid voltages at the proper level. Other contacts of the coast relay connect a shunt resistor across the grid of the second d-c amplifier to reduce the gain of that stage during the coast time and thus keep the coast rate smooth.

d. Calibrate Relay. When the RANGE CALIBRATE switch on the control panel is thrown to the ON position, the range calibrate relay K2104 is energized. This discharges the storage network and causes the delay time of the sawtooth delay circuits to be fixed and independent of the tracker output. The range handwheels may then be turned to make the indicated range and the N^2 gate range coincide. This selects the proper point on the sine wave for the servo tracker to follow.

SECTION V
POWER SUPPLIES

133. RANGE POWER SUPPLY.

The range power unit (fig. 138) contains three rectifiers: the low-voltage supply for the vacuum tube circuits in the range unit and the range indicator, the negative high-voltage rectifier for the range indicator tubes and for multivibrator bias in the range unit, and the rectifier for the motor and generator fields in the range indicator unit. The complete schematic diagram is shown in figure 144.

a. Low-voltage Rectifier. The low-voltage rectifier is an electronically regulated power supply. It consists of the full-wave rectifier tube V804, the regulating tubes V805, V806, and V807, the control tube V808, and the voltage regulator tube V809. The operation of this regulated power supply is the same as the operation of the one discussed in paragraph 156**e**. Two outputs are taken from this stage, regulated 250 volts, and unregulated 400 volts.

b.' High-voltage Rectifier. The negative 2,000 volts for the operation of the range indicator cathode-ray tubes and the negative bias voltages for the range unit multivibrators are supplied by the high-voltage rectifier tube V810. This rectifier is a half-wave rectifier with a simple resistance-capacitance filter. R-C filtering is adequate here, for the current drain from this supply is low enough that the voltage across the capacitors changes very little. The output of this rectifier –2,000 volts, –100 volts, –13 volts, and –5 volts are taken from points on the bleeder resistor and are used in the range unit.

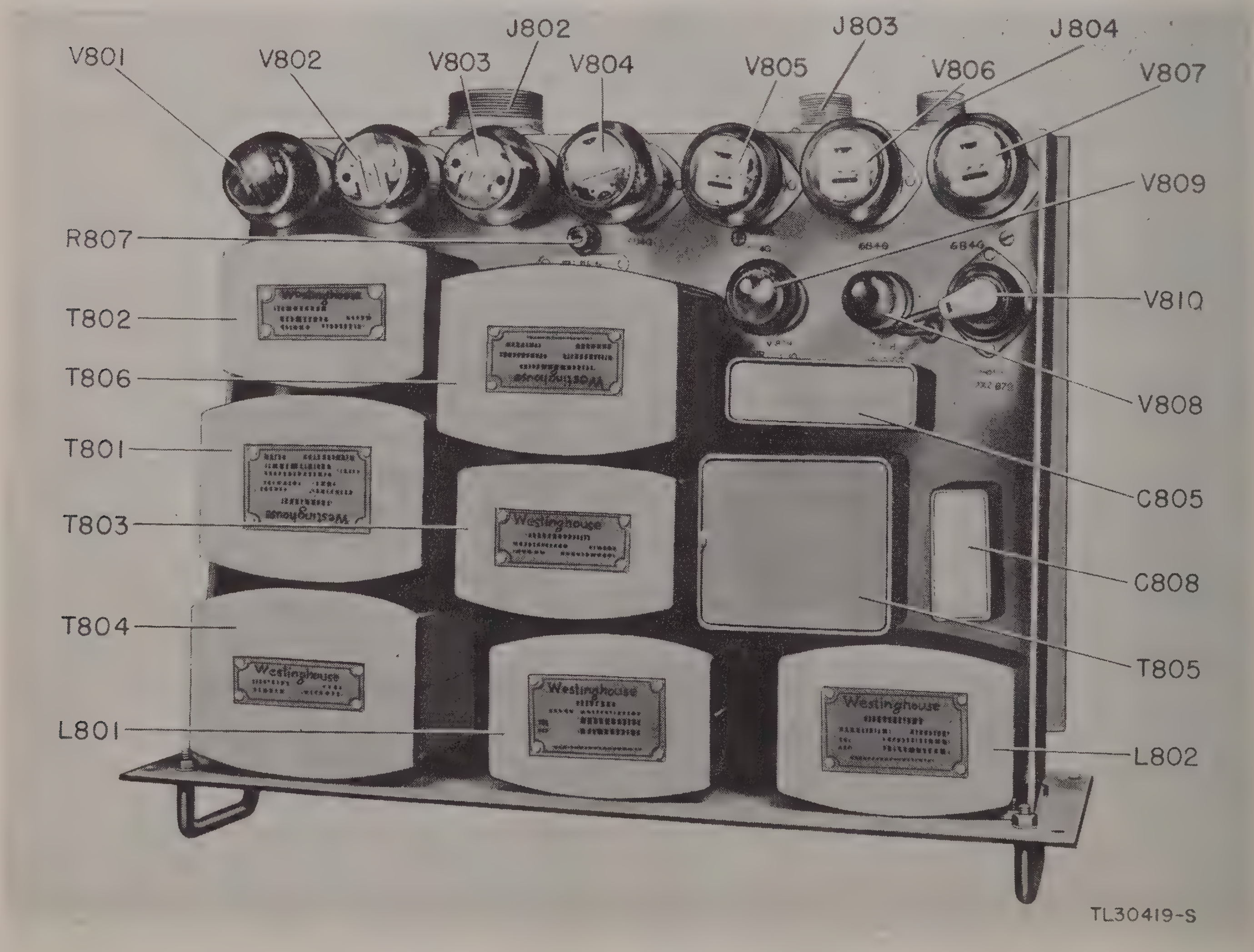

Figure 138. Range power supply, top view.

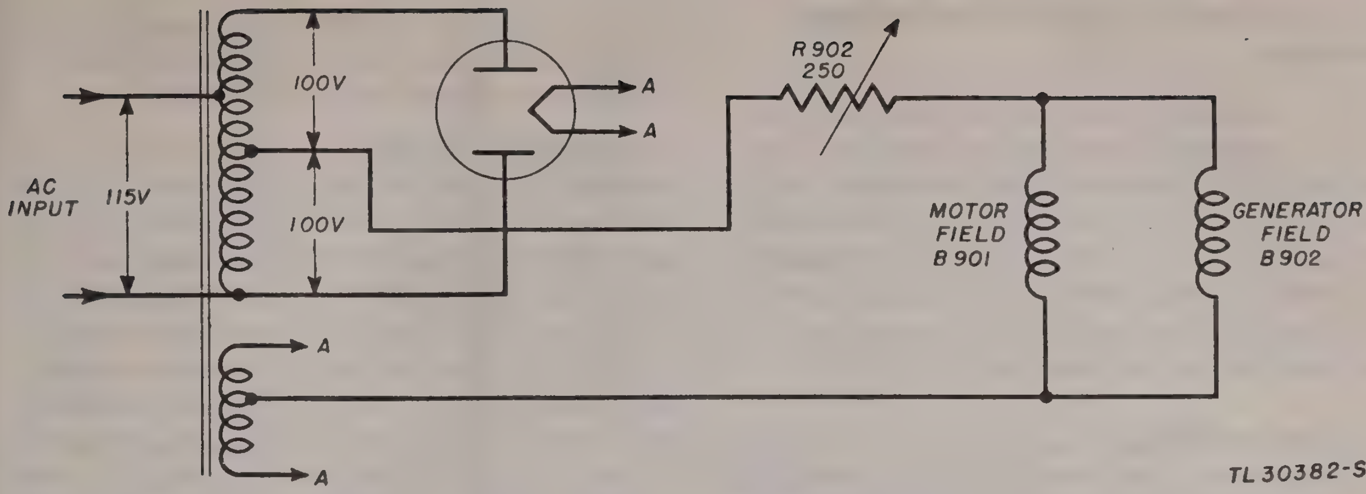

Figure 139. Field rectifier for motor and generator fields.

c. Field Rectifier (fig. 139). The field current for the motor and generator in the range indicator is supplied by the gas rectifier tube V801 (fig. 144). The output current from this full-wave rectifier is applied to the fields through the regulating resistor R902, which controls the maximum motor speed by controlling field current. Plate voltage for the full-wave rectifier is taken from the auto transformer T801. The two remaining tubes, V802 and V803 are not used in the SCR-784.

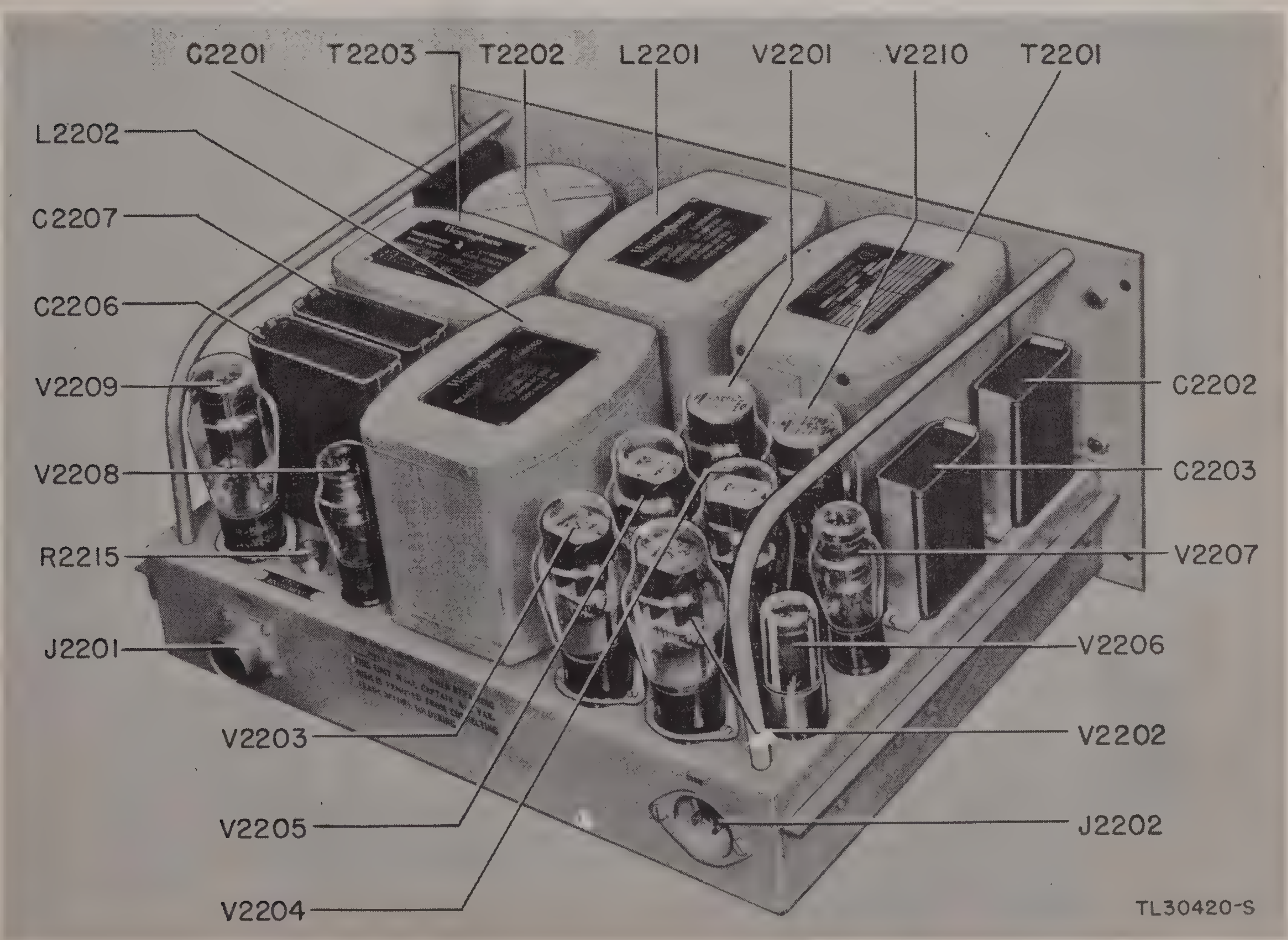

Figure 140. ART power supply, top view.

134. AUTOMATIC RANGE TRACKING UNIT RECTIFIER.

The auto range power supply (fig. 140) contains a positive output and a negative output rectifier. The positive supply provides a regulated and an unregulated voltage for the operation of the vacuum tube circuits in the automatic range tracking unit. The negative supply provides the regulated negative voltage used in the automatic range tracking unit.

a. Positive Voltage Supply. The positive supply uses tubes V2201 and V2210 in parallel as a full-wave rectifier with high current capacity (fig. 145). Regulating tubes V2202, V2203, V2204, V2205, control tube V2206, and regulator tube V2207, control the output voltage, in the same manner as explained in paragraph 156**e.**

b. Negative Supply. The negative voltage is furnished by rectifier tube V2209, connected as a full-wave rectifier with the two section choke input filter feeding the regulator tube and the dropping resistor R2220. The regulator tube maintains a constant drop across its terminals. Thus, as the rectifier output voltage changes, the regulator tube voltage cannot change; so the voltage drop across the regulating resistor R2220 changes to correct the change in the rectifier voltage. The output of this stage is a constant –105 volts.

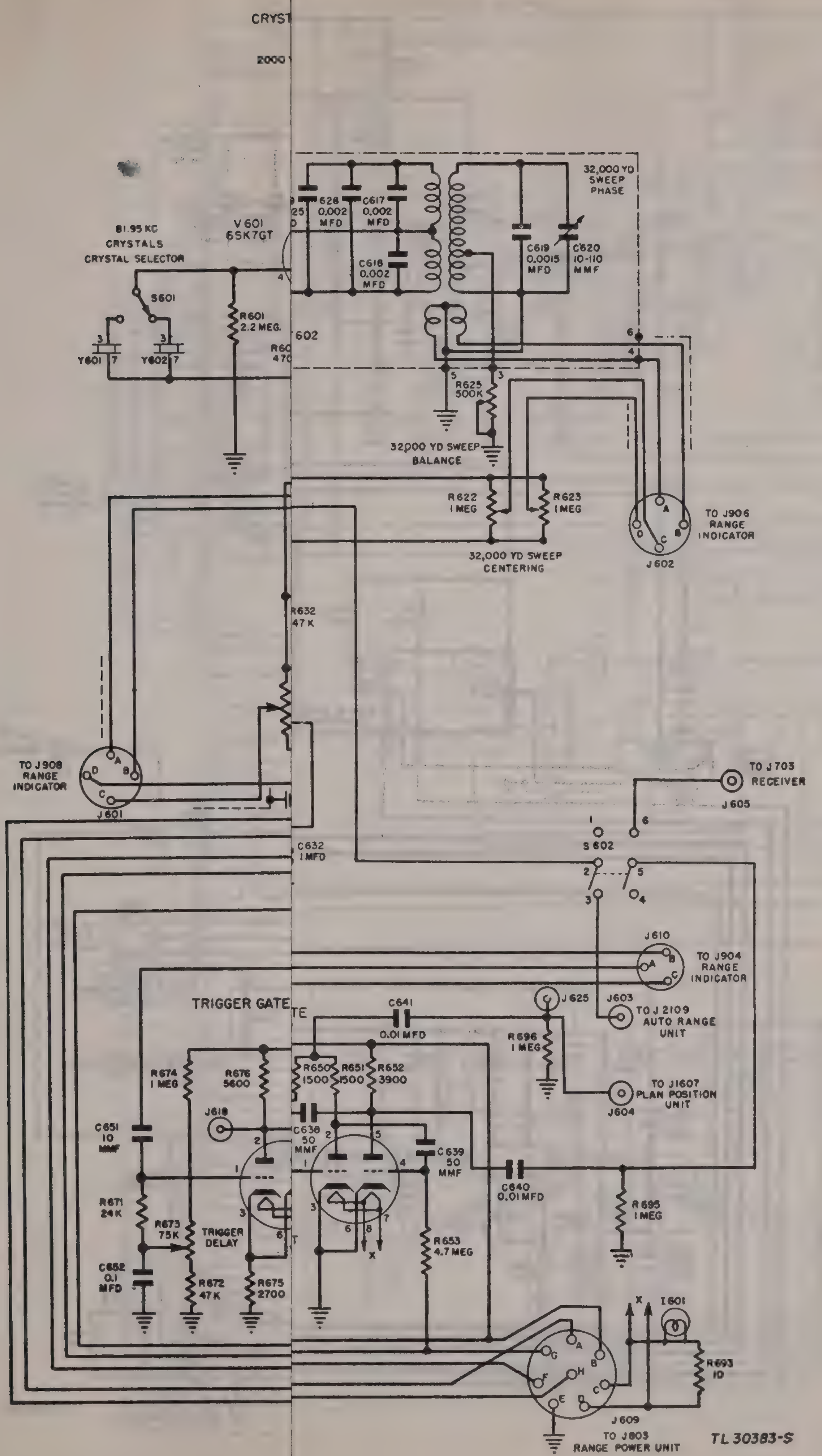

Figure 141. Range unit, complete schematic diagram.

134. AUTOMATIC RANGE TRACKING UNIT RECTIFIER.

The auto range power supply (fig. 140) contains a positive output and a negative output rectifier. The positive supply provides a regulated and an unregulated voltage for the operation of the vacuum tube circuits in the automatic range tracking unit. The negative supply provides the regulated negative voltage used in the automatic range tracking unit.

a. Positive Voltage Supply. The positive supply uses tubes V2201 and V2210 in parallel as a full-wave rectifier with high current capacity (fig. 145). Regulating tubes V2202, V2203, V2204, V2205, control tube V2206, and regulator tube V2207, control the output voltage, in the same manner as explained in paragraph 156**e.**

b. Negative Supply. The negative voltage is furnished by rectifier tube V2209, connected as a full-wave rectifier with the two section choke input filter feeding the regulator tube and the dropping resistor R2220. The regulator tube maintains a constant drop across its terminals. Thus, as the rectifier output voltage changes, the regulator tube voltage cannot change; so the voltage drop across the regulating resistor R2220 changes to correct the change in the rectifier voltage. The output of this stage is a constant –105 volts.

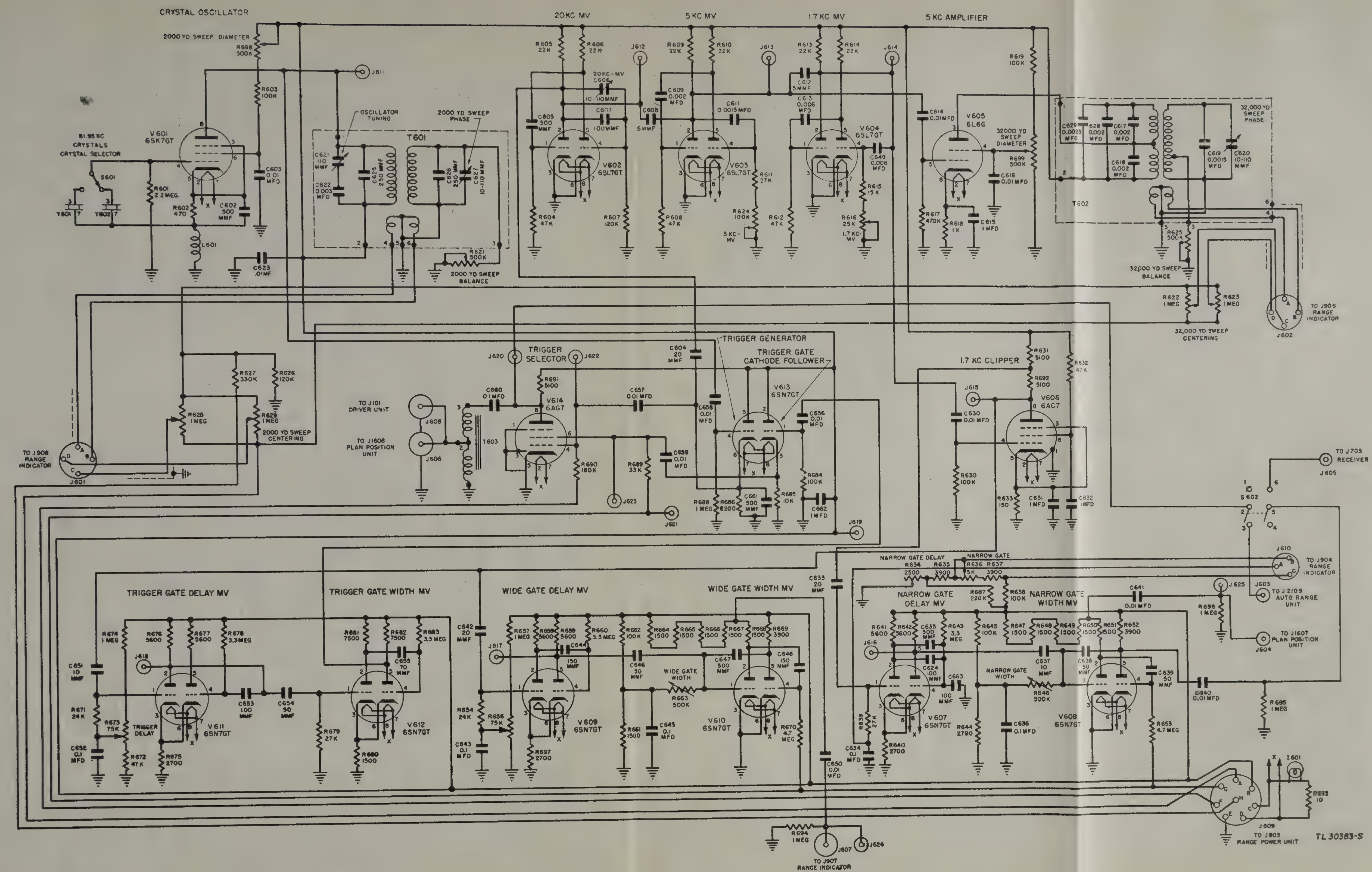

Figure 141. Range unit, complete schematic diagram.

Figure 141. Range unit, complete schematic diagram.

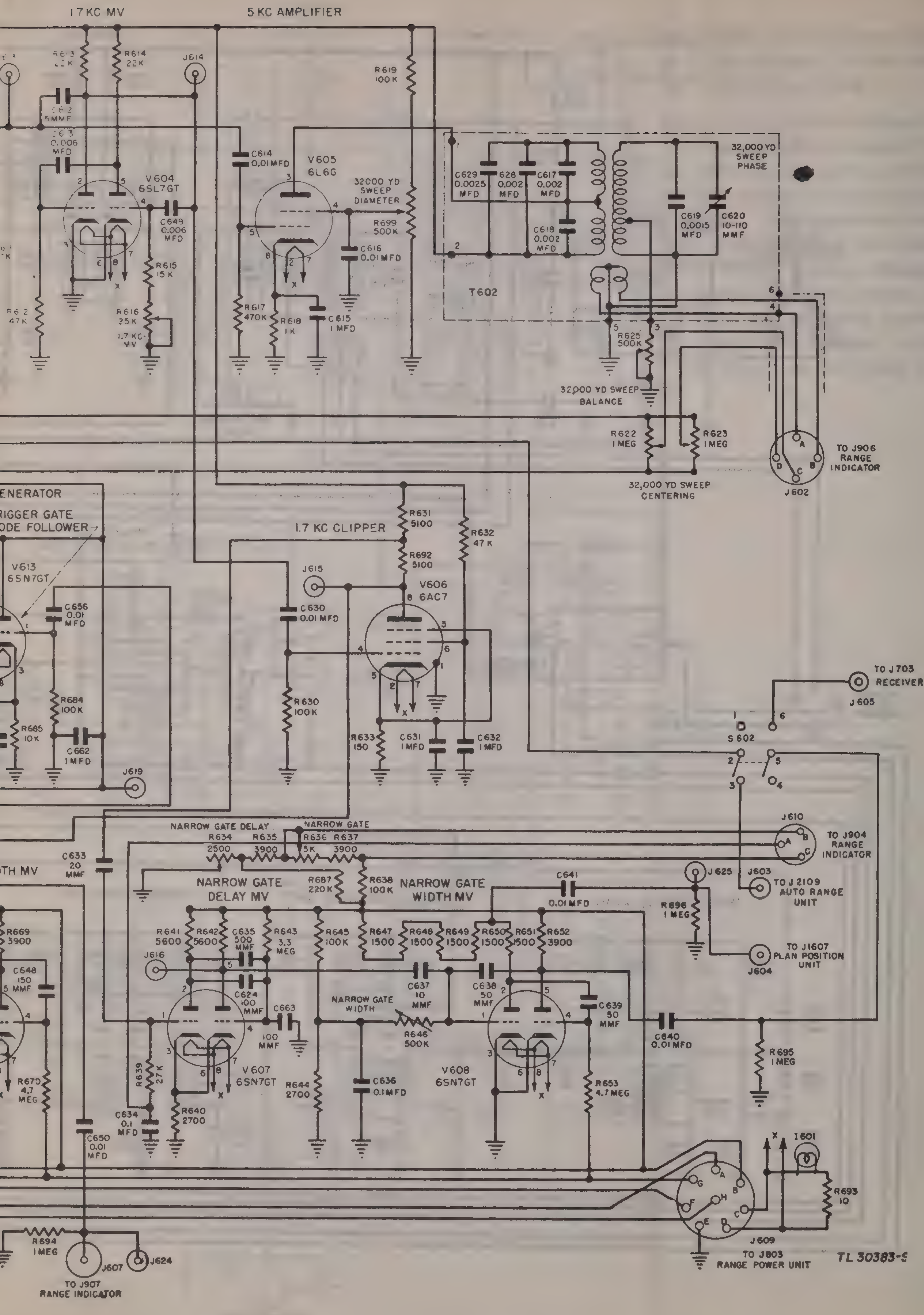

Figure 141. Range unit, complete schematic diagram.

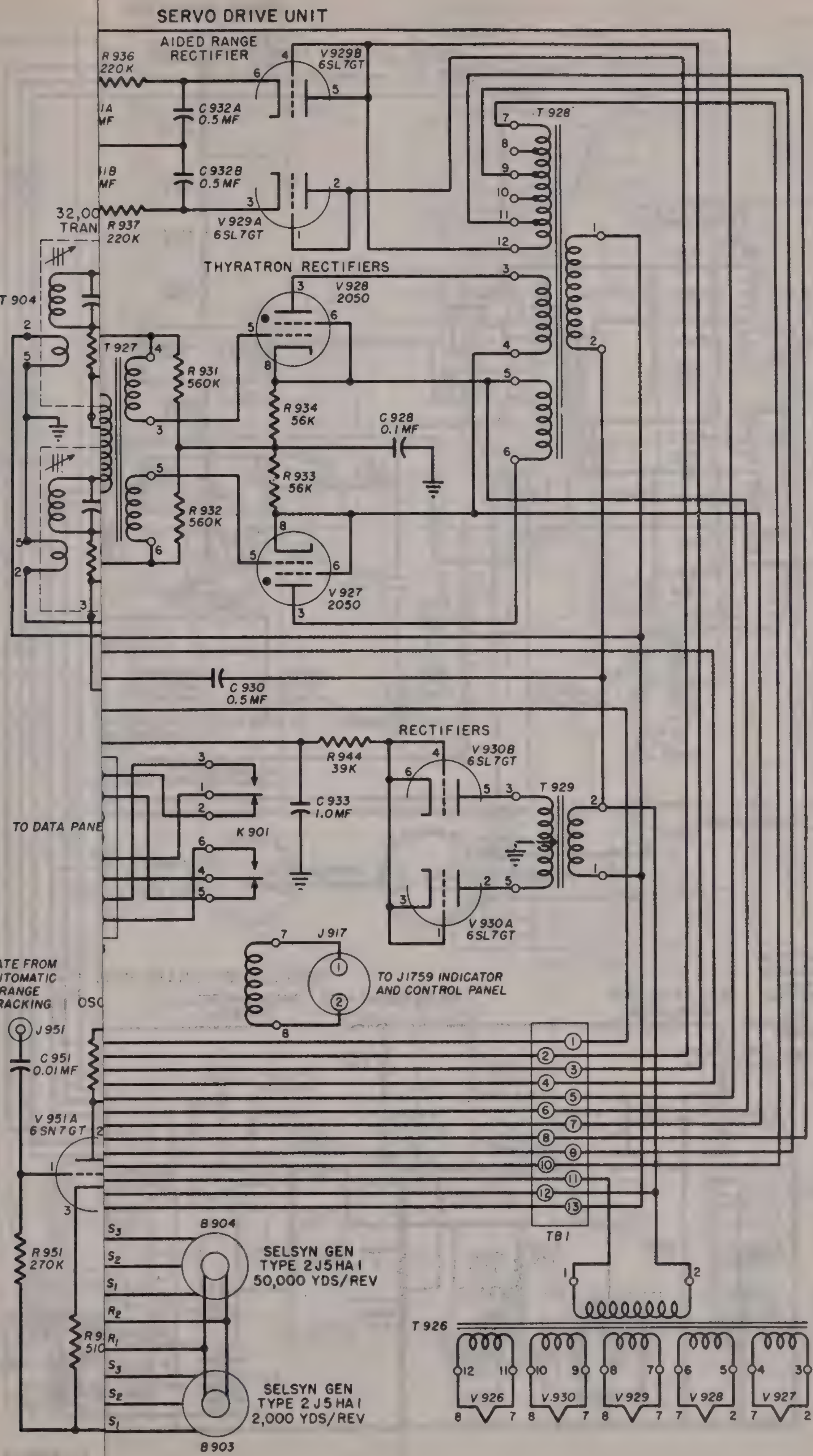

Figure 142. Range indicator unit, complete schematic diagram.

Figure 141. Range unit, complete schematic diagram.

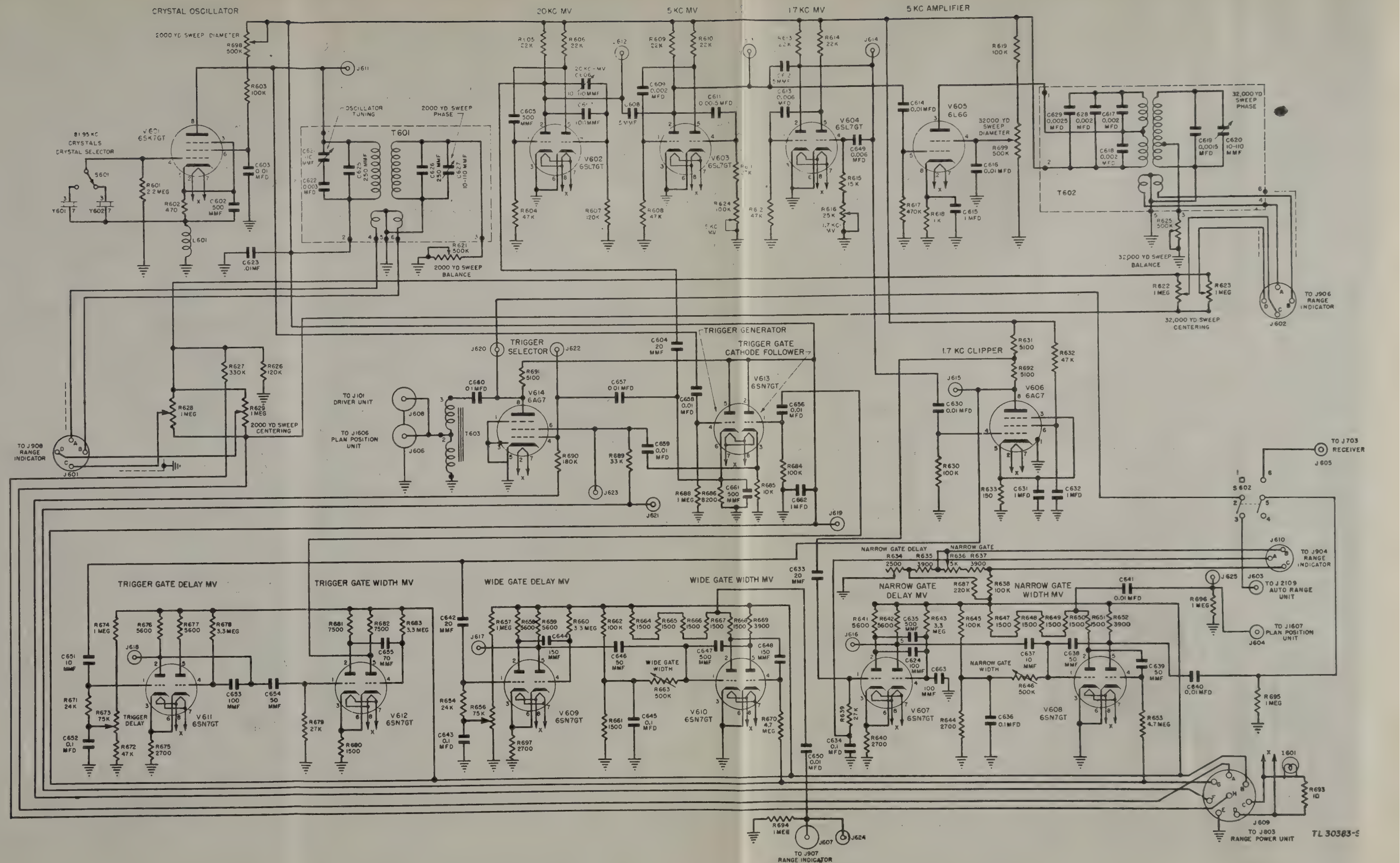

Figure 141. Range unit, complete schematic diagram.

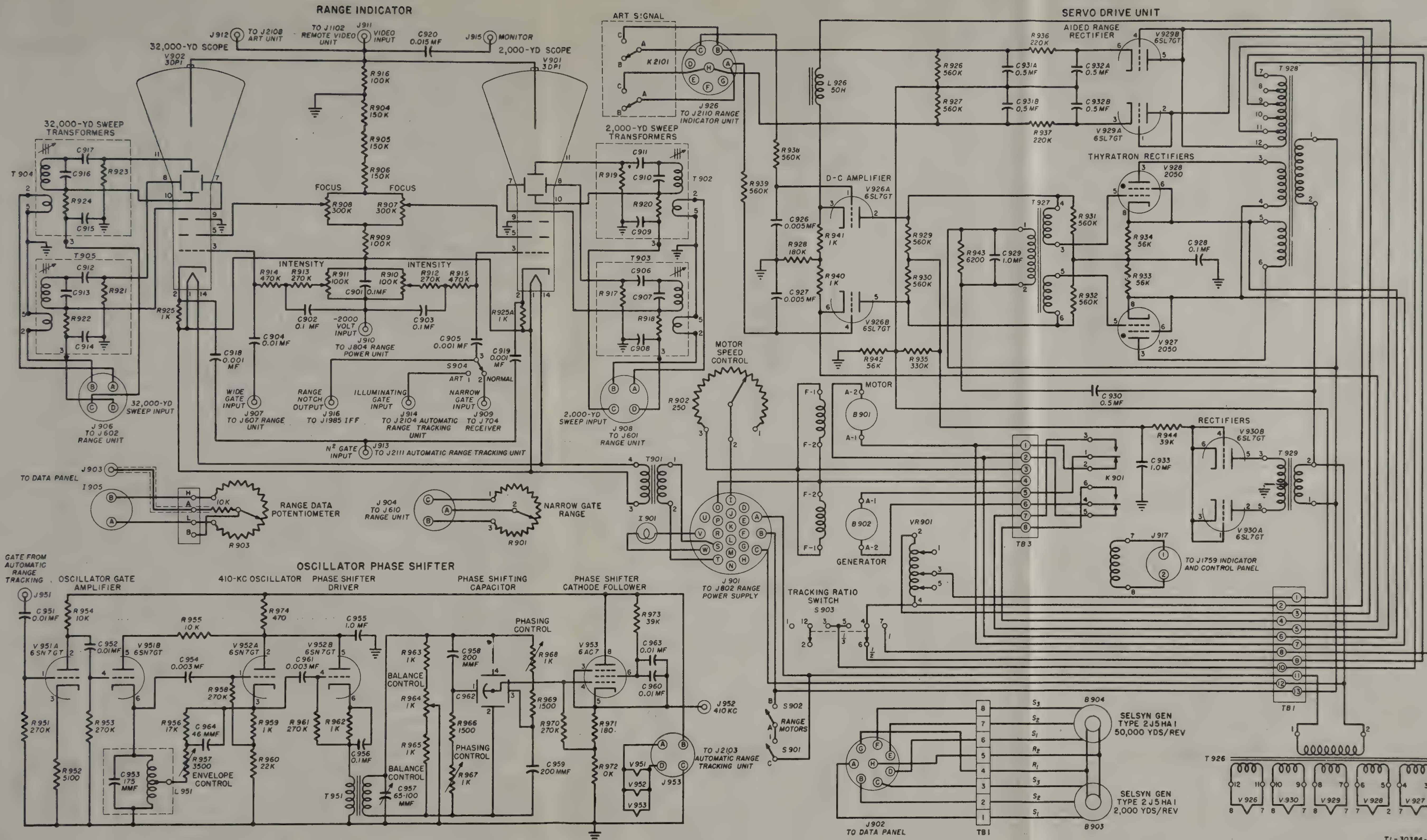

Figure 142. Range indicator unit, complete schematic diagram.

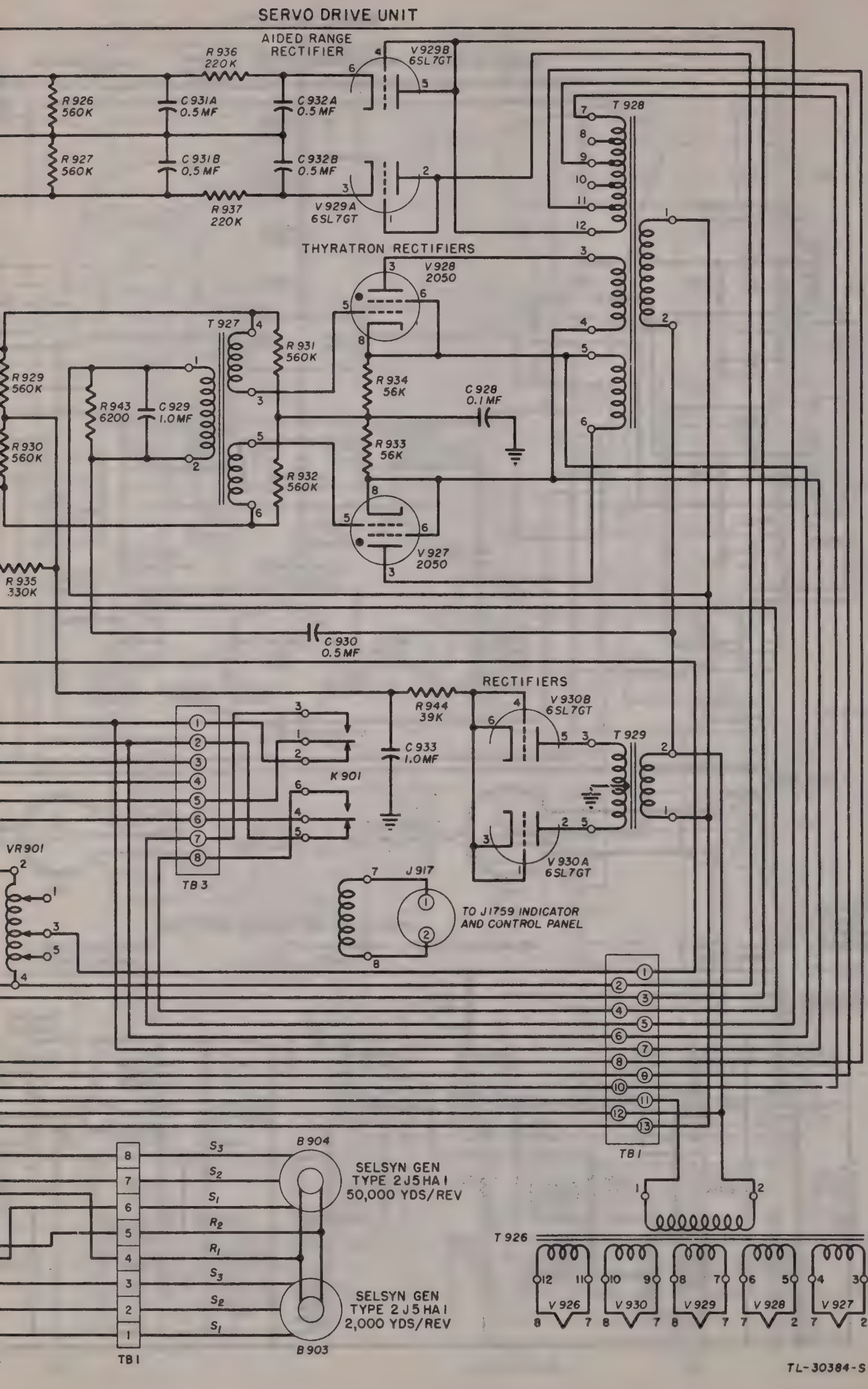

Figure 142. Range indicator unit, complete schematic diagram.

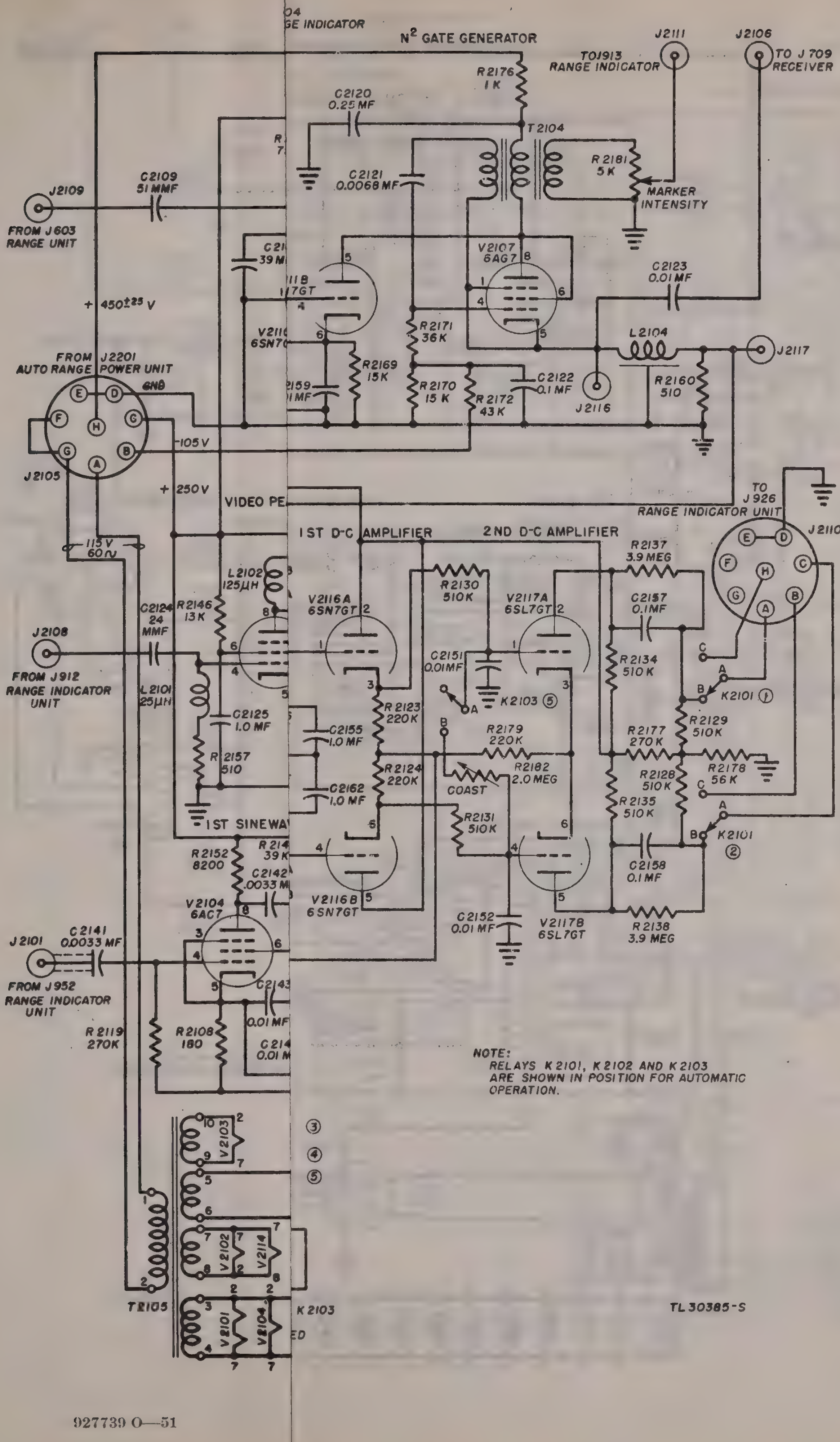

Figure 143. ART unit, complete schematic diagram.

Figure 142. Range indicator unit, complete schematic diagram.

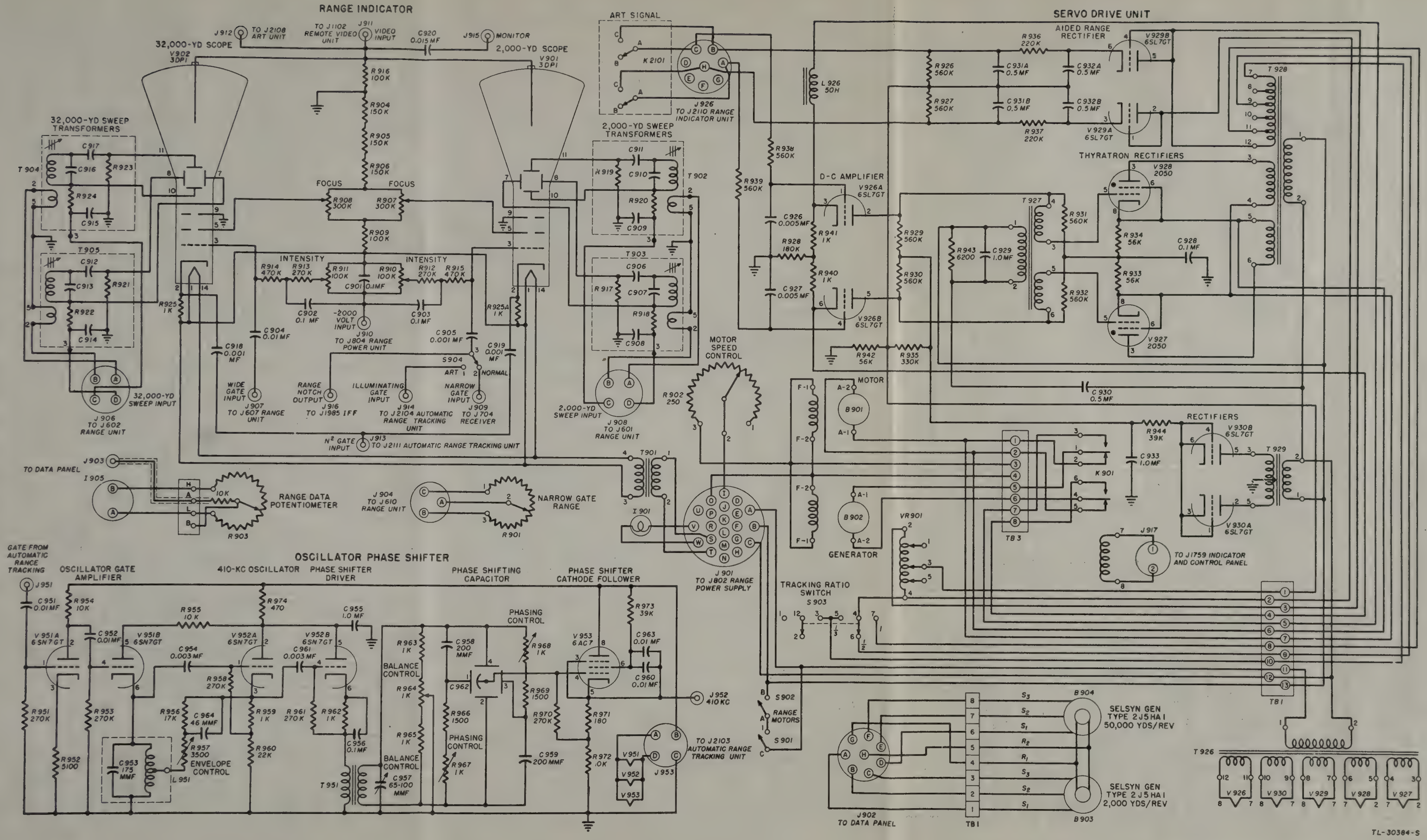

Figure 142. Range indicator unit, complete schematic diagram.

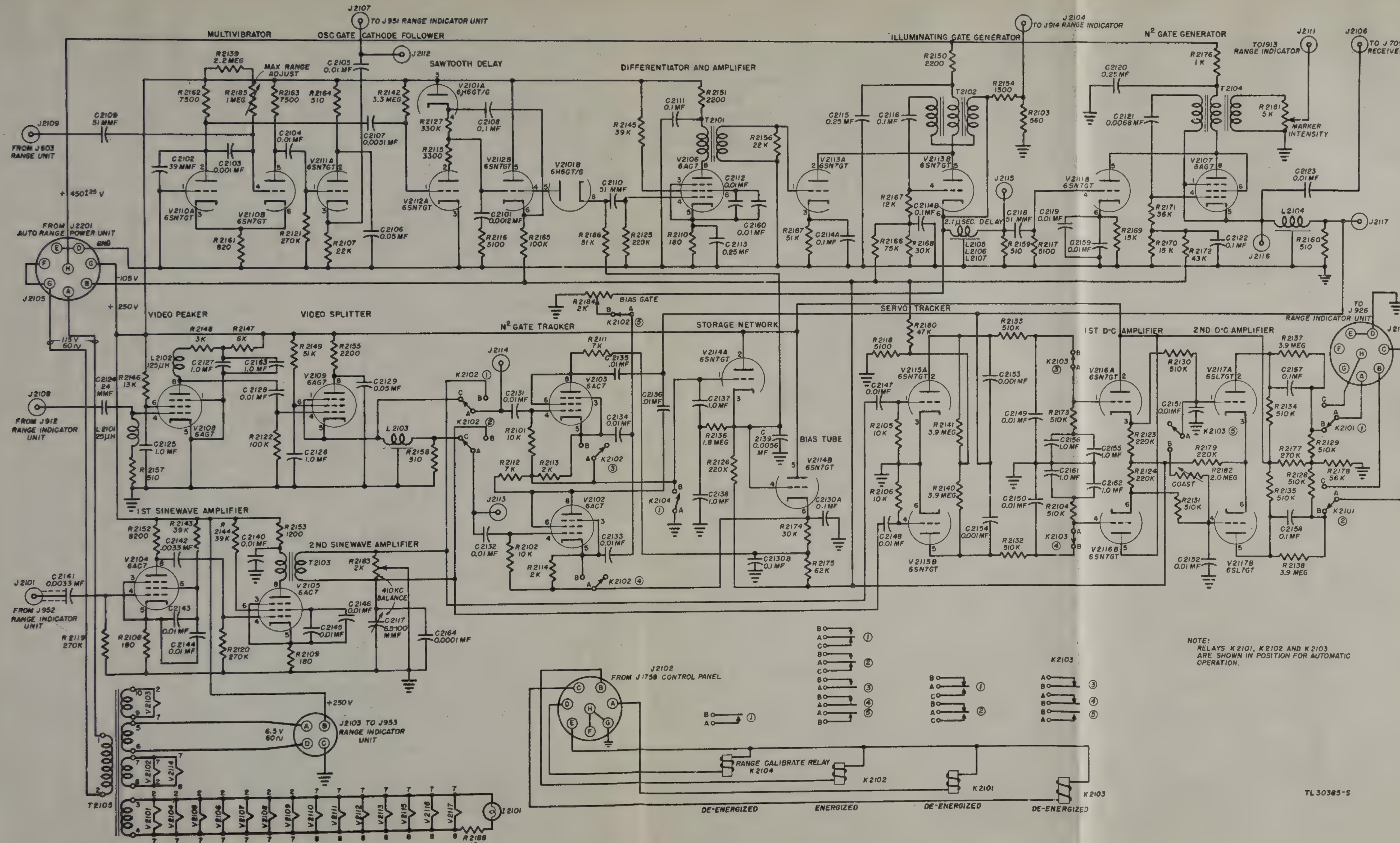

Figure 143. ART unit, complete schematic diagram.

Figure 143. ART unit, complete schematic diagram.

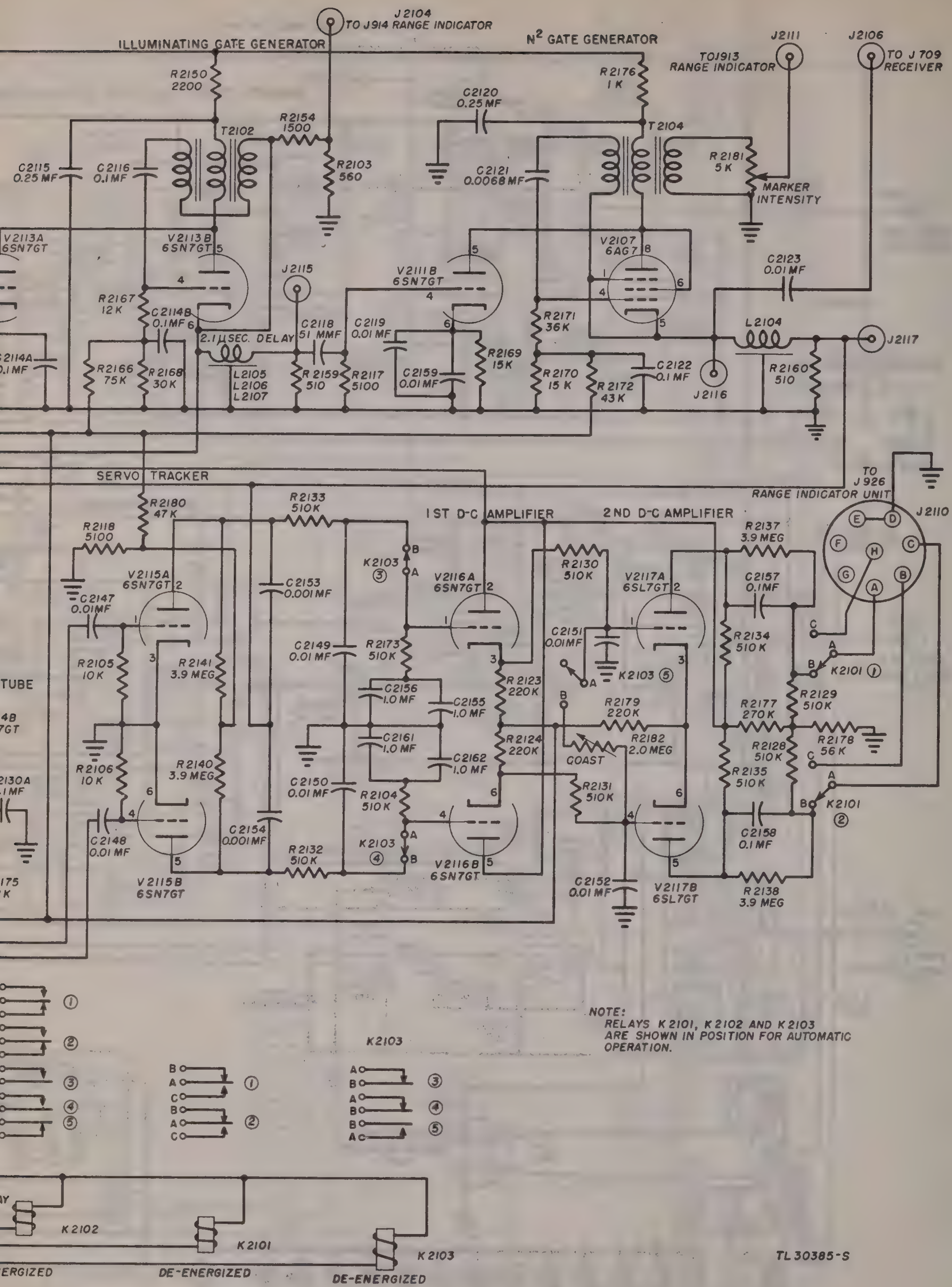

Figure 143. ART unit, complete schematic diagram.

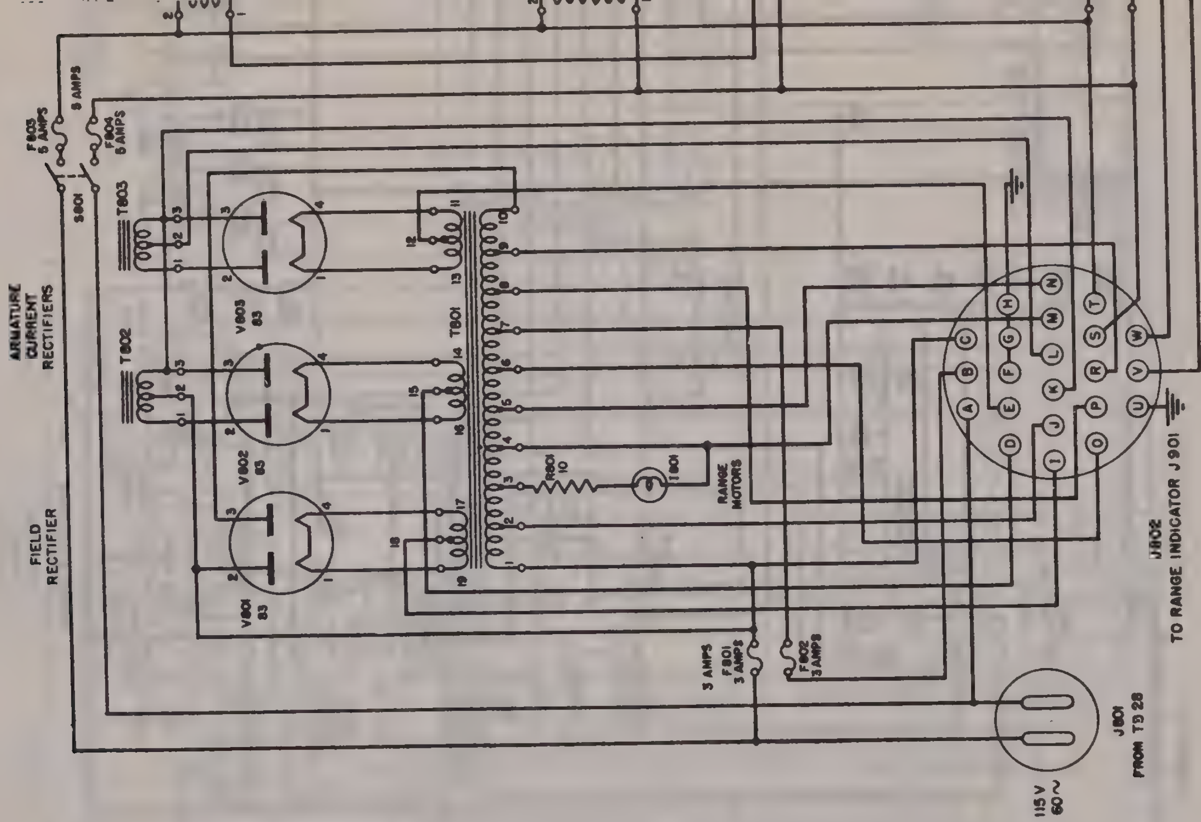

Figure 144. Range power supply, complete schematic diagram.

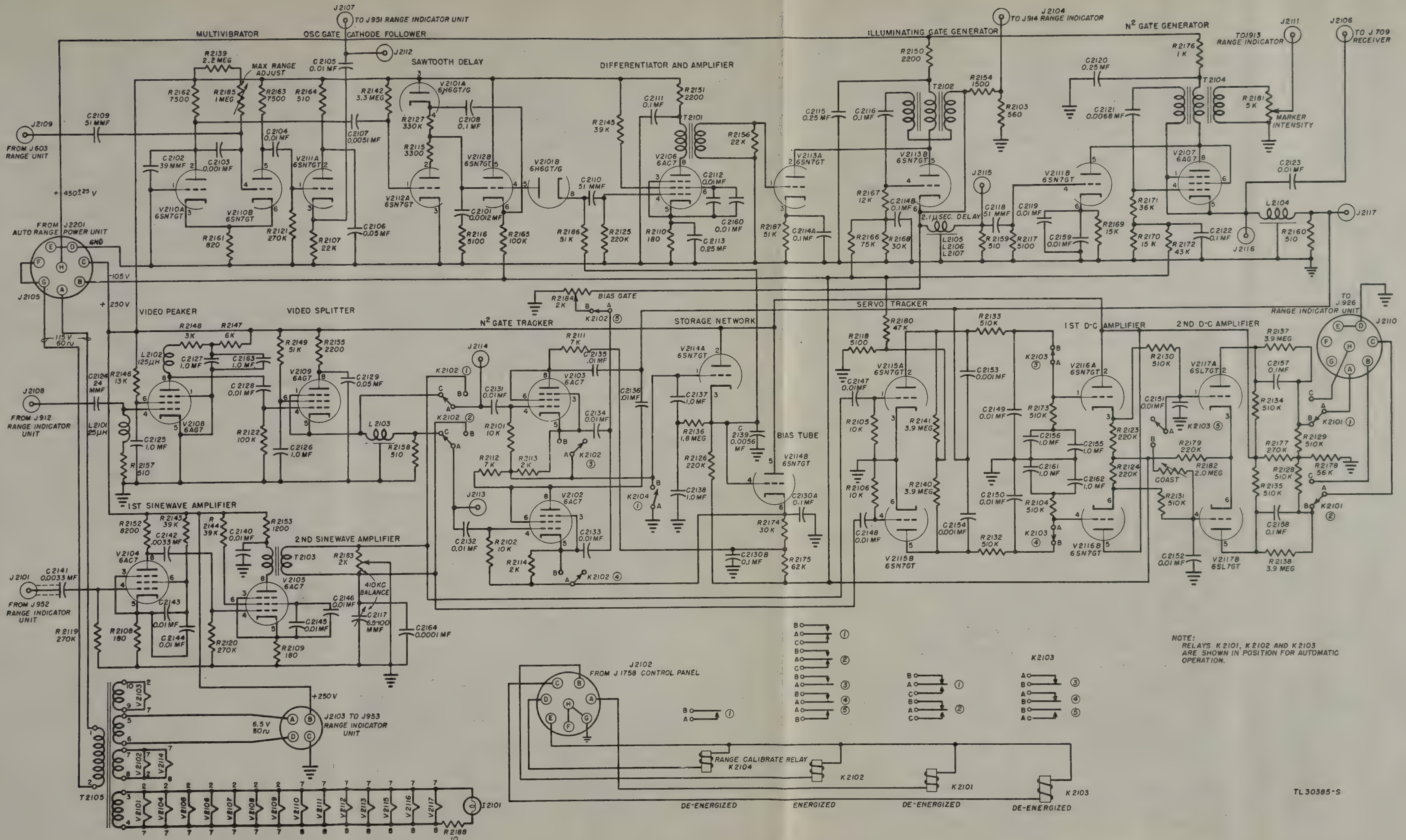

Figure 143. ART unit, complete schematic diagram.

Figure 143. ART unit, complete schematic diagram.

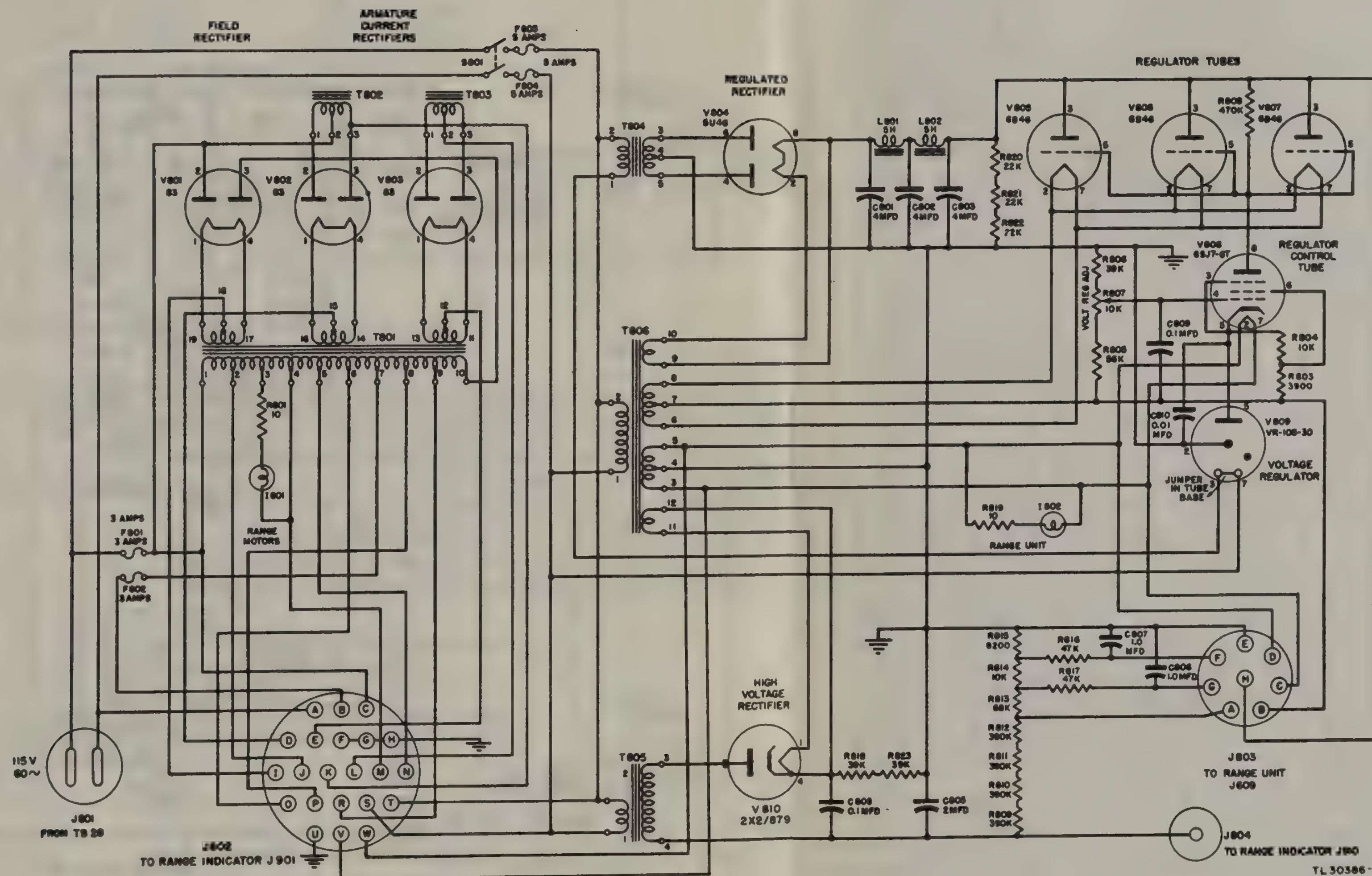

Figure 144. Range power supply, complete schematic diagram.

Figure 144. Range power supply, complete schematic diagram.

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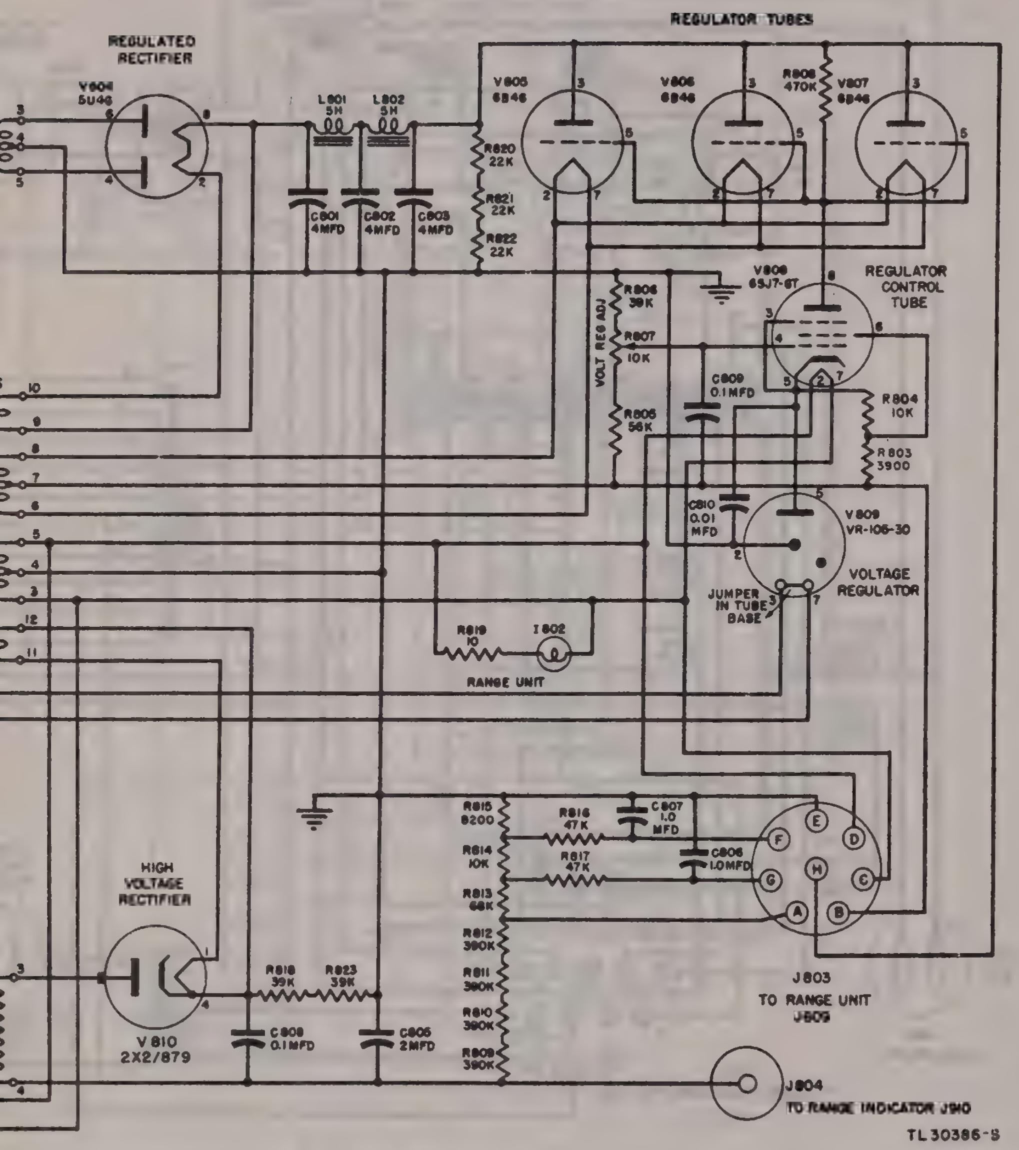

Figure 144. Range power supply, complete schematic diagram.

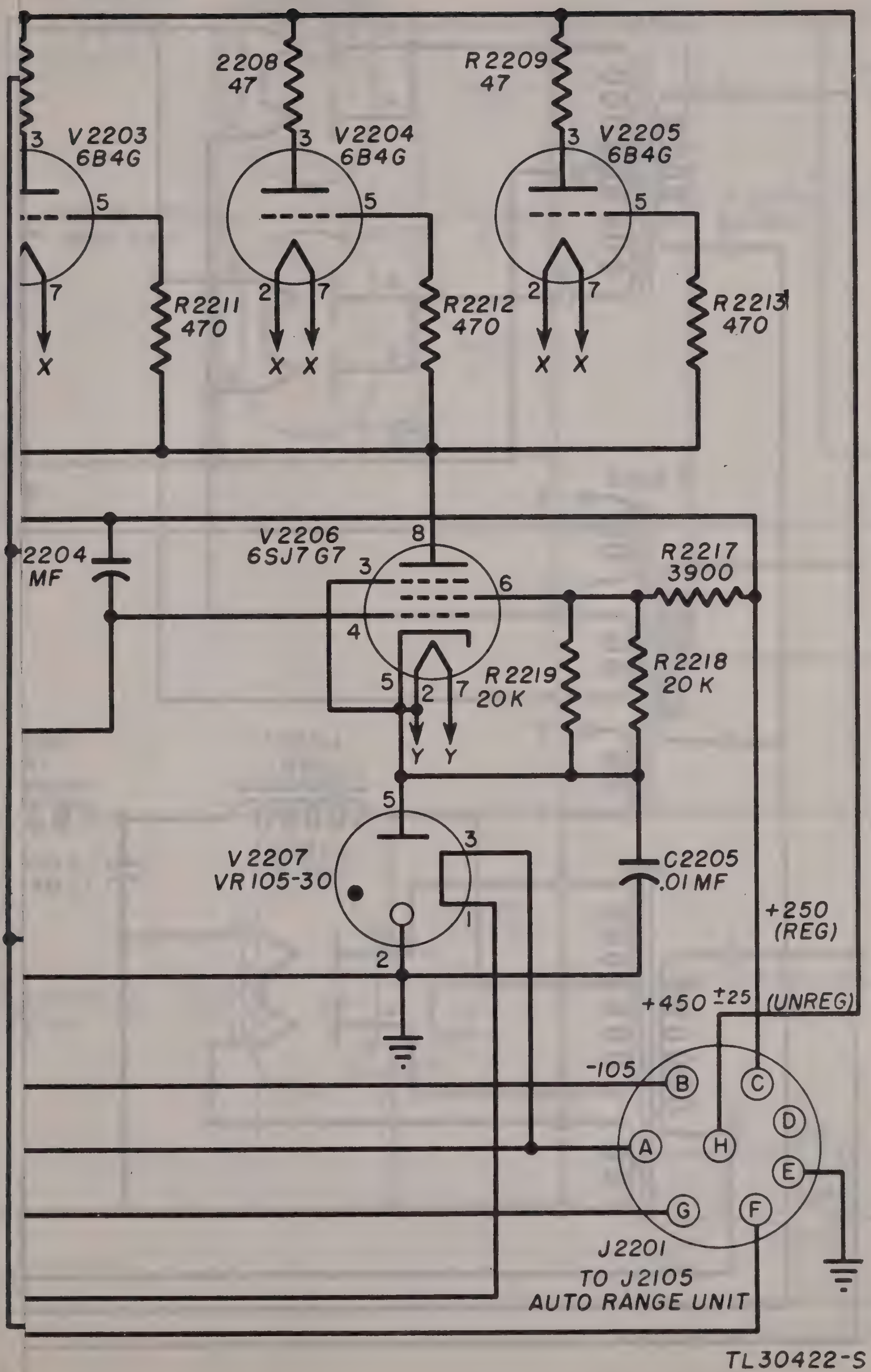

Figure 145. ART power supply, complete schematic diagram.

Figure 144. Range power supply, complete schematic diagram.

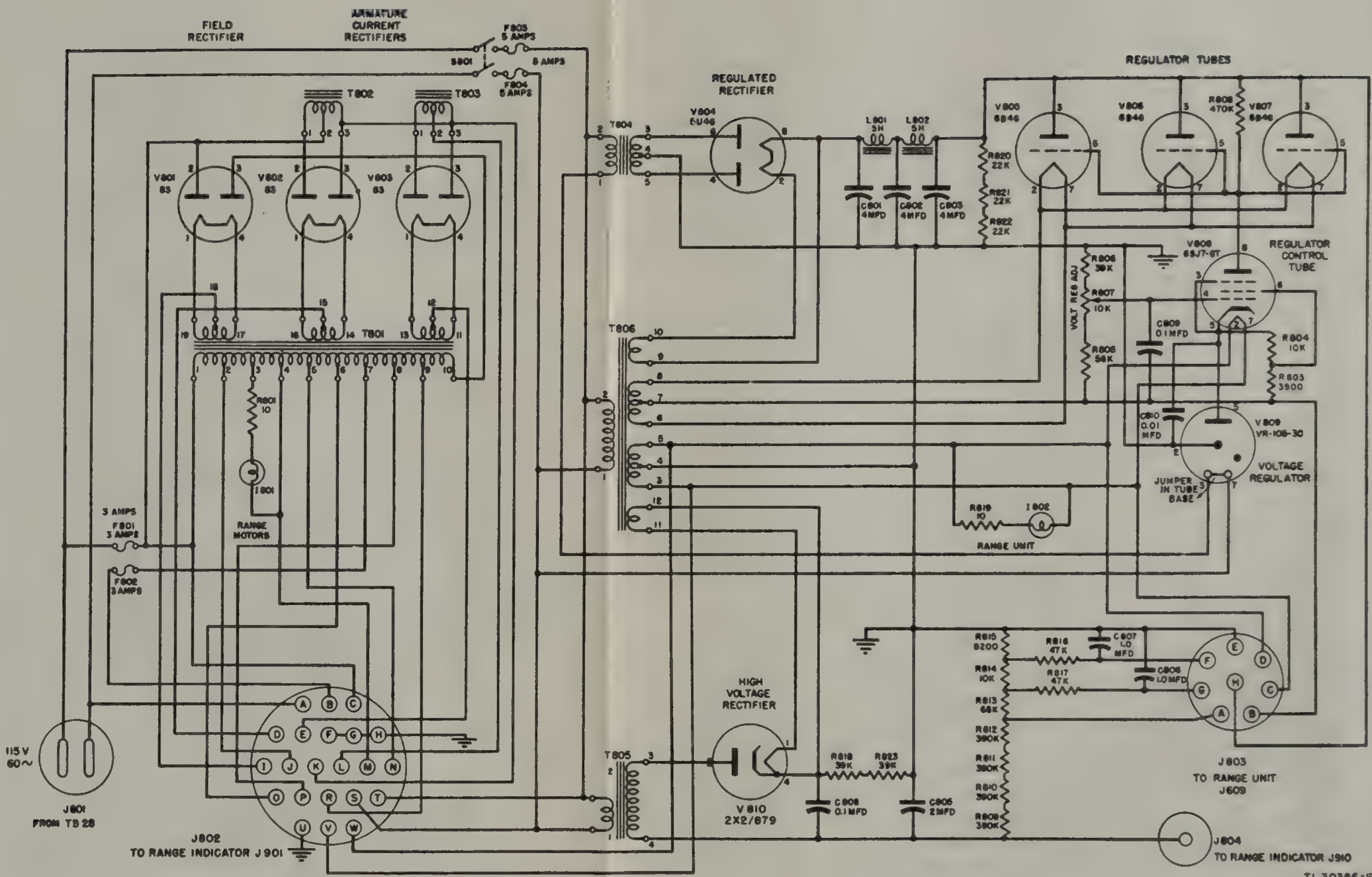

Figure 144. Range power supply, complete schematic diagram.

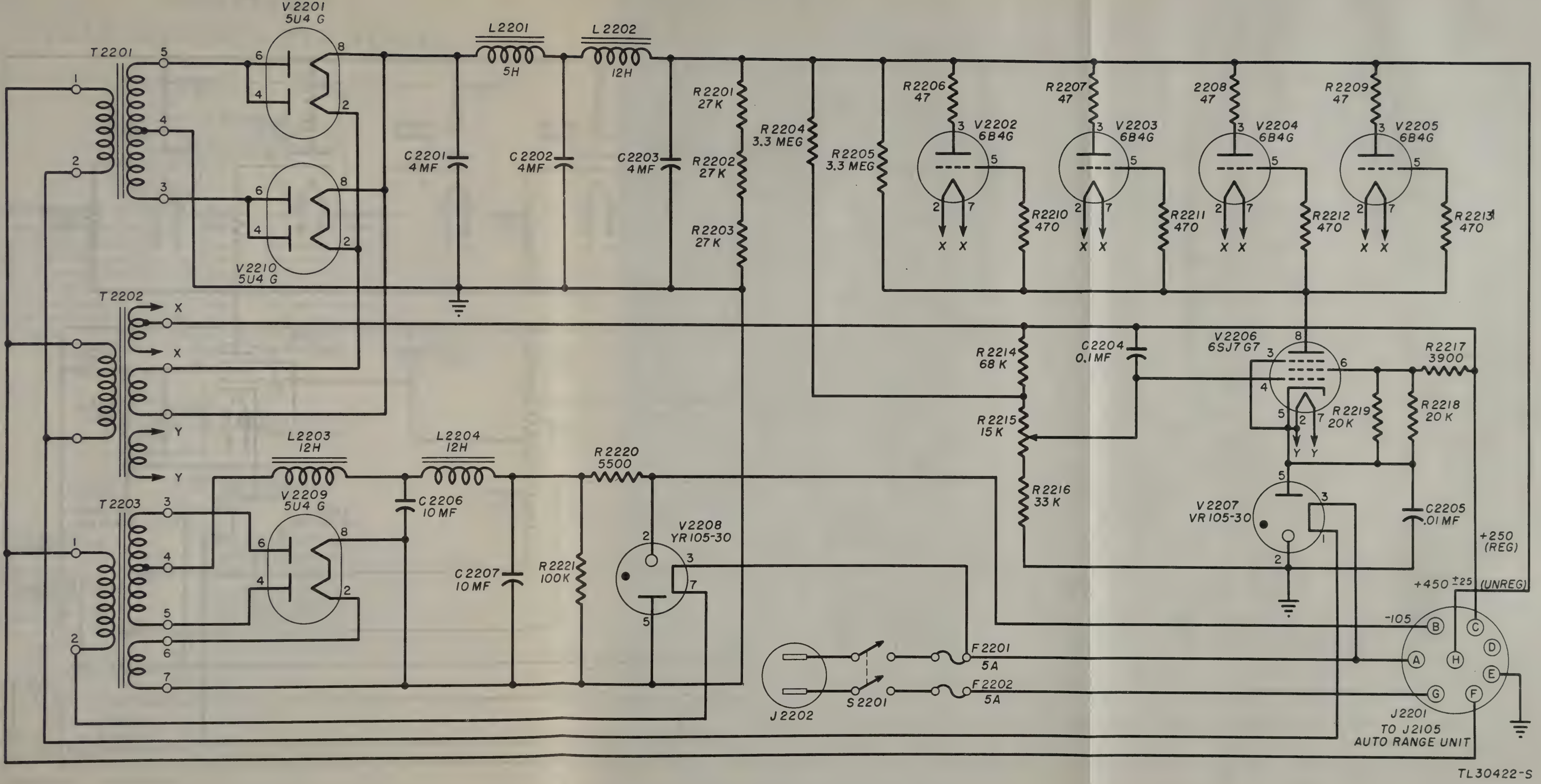

Figure 145. ART power supply, complete schematic diagram.

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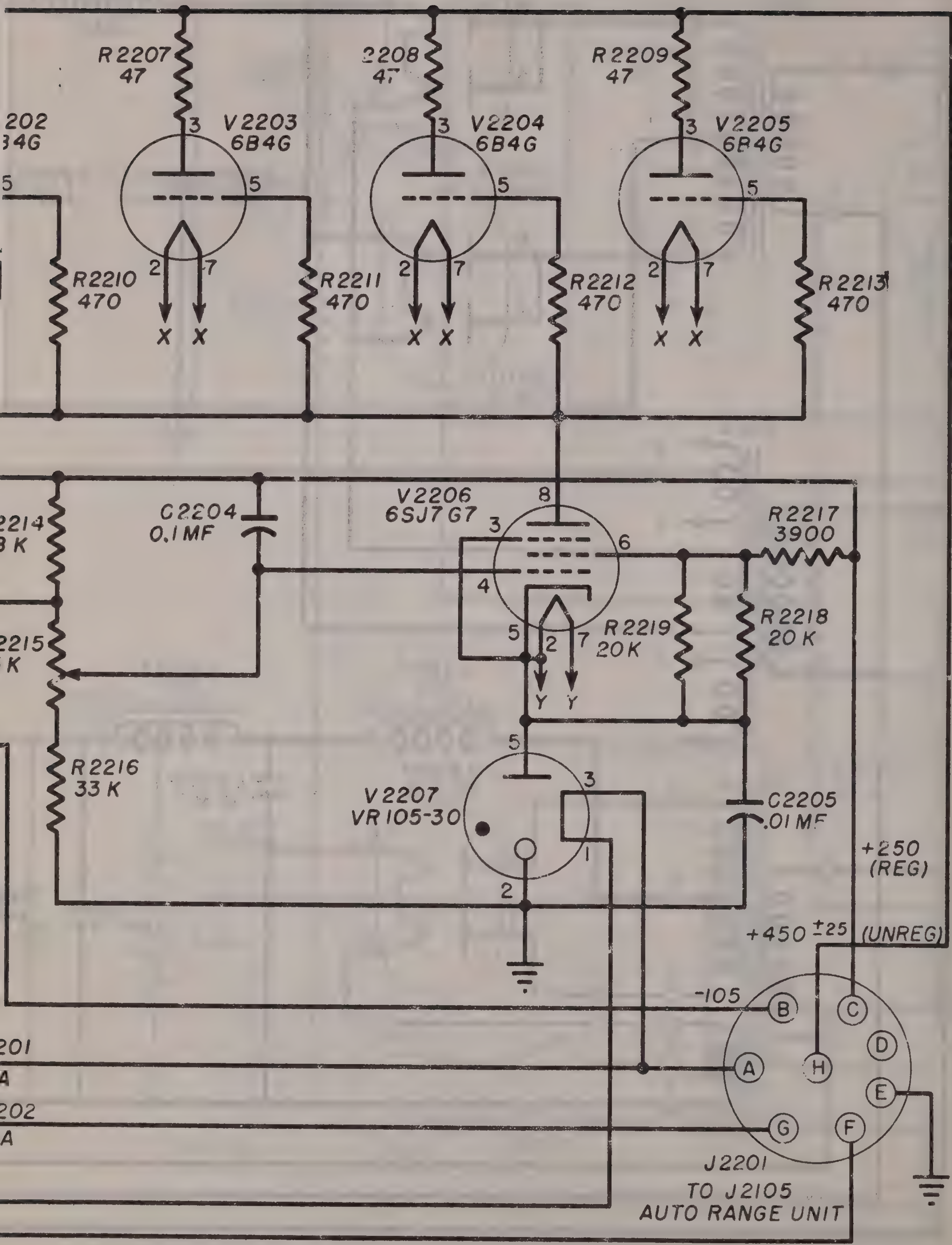

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Figure 145. ART power supply, complete schematic diagram.

CHAPTER 6
PLAN POSITION (PPI) SYSTEM

SECTION I
INTRODUCTION

135. SIMPLIFIED BLOCK DIAGRAM.

The components of the PPI system shown in the simplified block diagram (fig. 146) are used to produce a plan map on the face of the PPI tube (fig. 147) showing the location and range of all targets in the r-f beam. Targets are more easily located and detected on the PPI scope than on the range scopes; so the PPI system is used during searching operation to locate and select targets prior to switching to automatic tracking. The components of the PPI system are the PPI unit, PPI indicator, PPI power supply, and PPI selsyn. The location of these components is shown in figures 6 and 7 with the PPI selsyn located in the azimuth compartment in the antenna mount.

a. Plan Position Unit. This unit with its associated circuits uses the input signals and voltages from the range, remote video amplifier, power supply, and PPI selsyn producing the

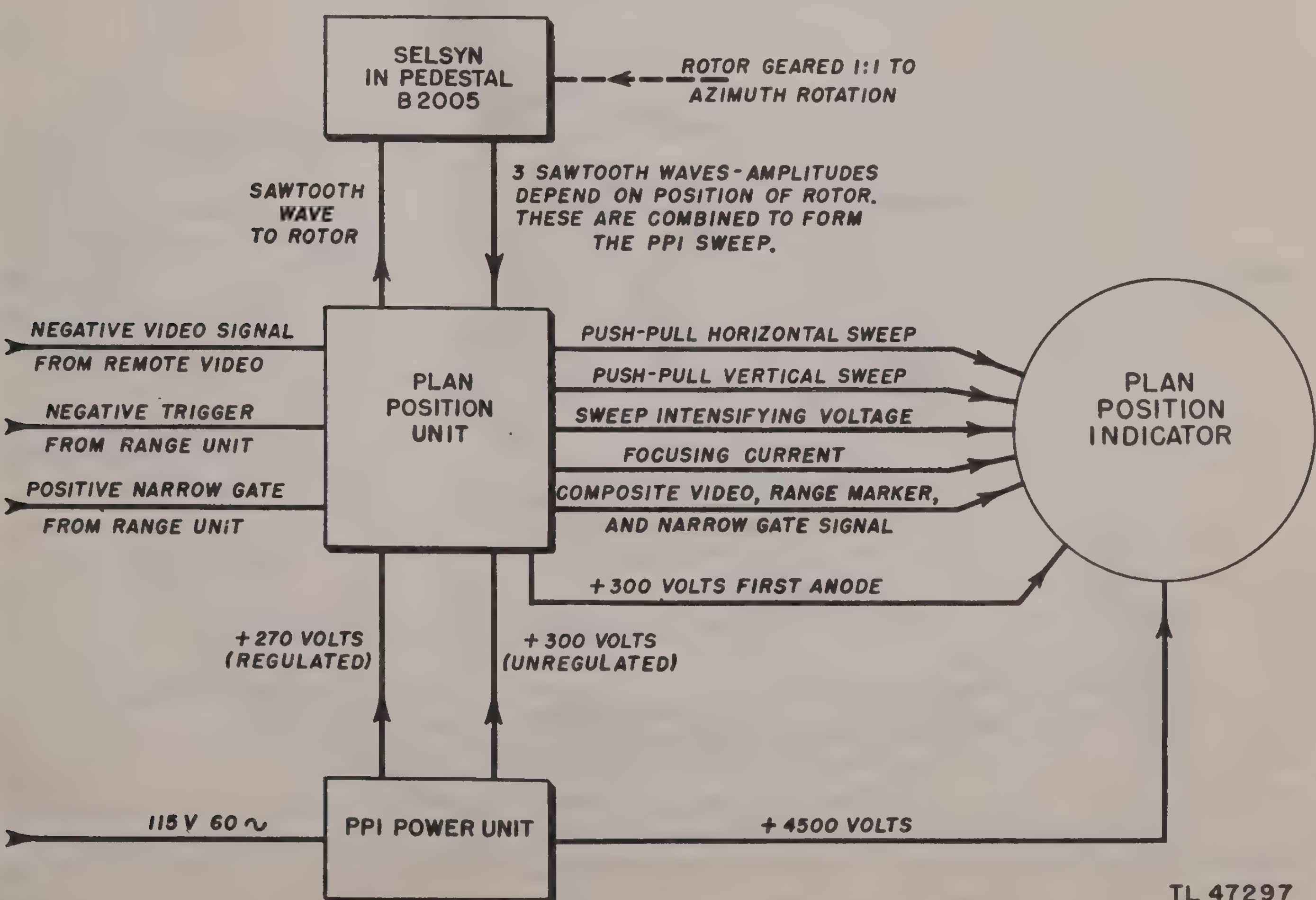

Figure 146. PPI system, simplified block diagram.

Figure 145. ART power supply, complete schematic diagram.

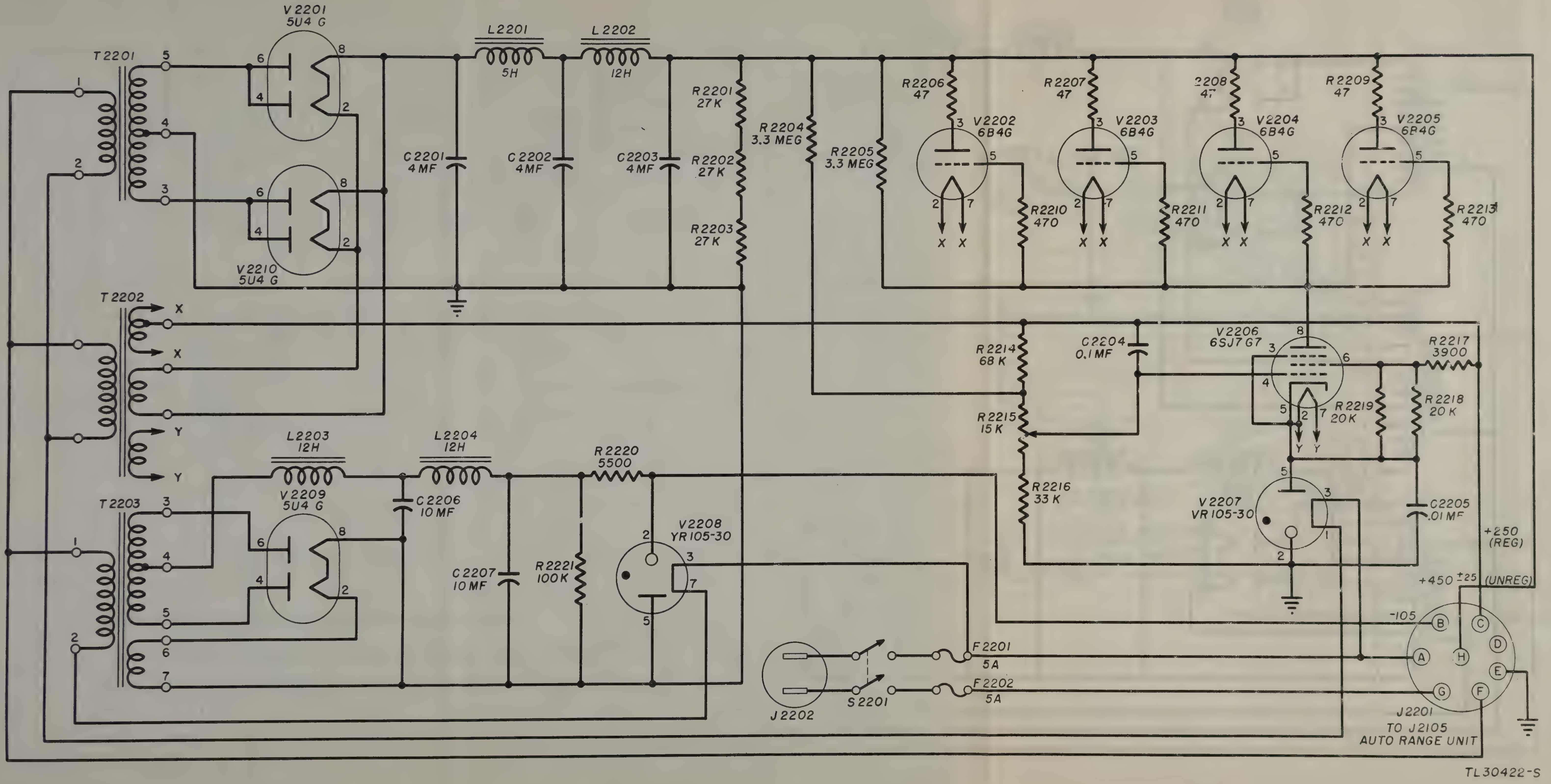

Figure 145. ART power supply, complete schematic diagram.

CHAPTER 6
PLAN POSITION (PPI) SYSTEM

SECTION I
INTRODUCTION

135. SIMPLIFIED BLOCK DIAGRAM.

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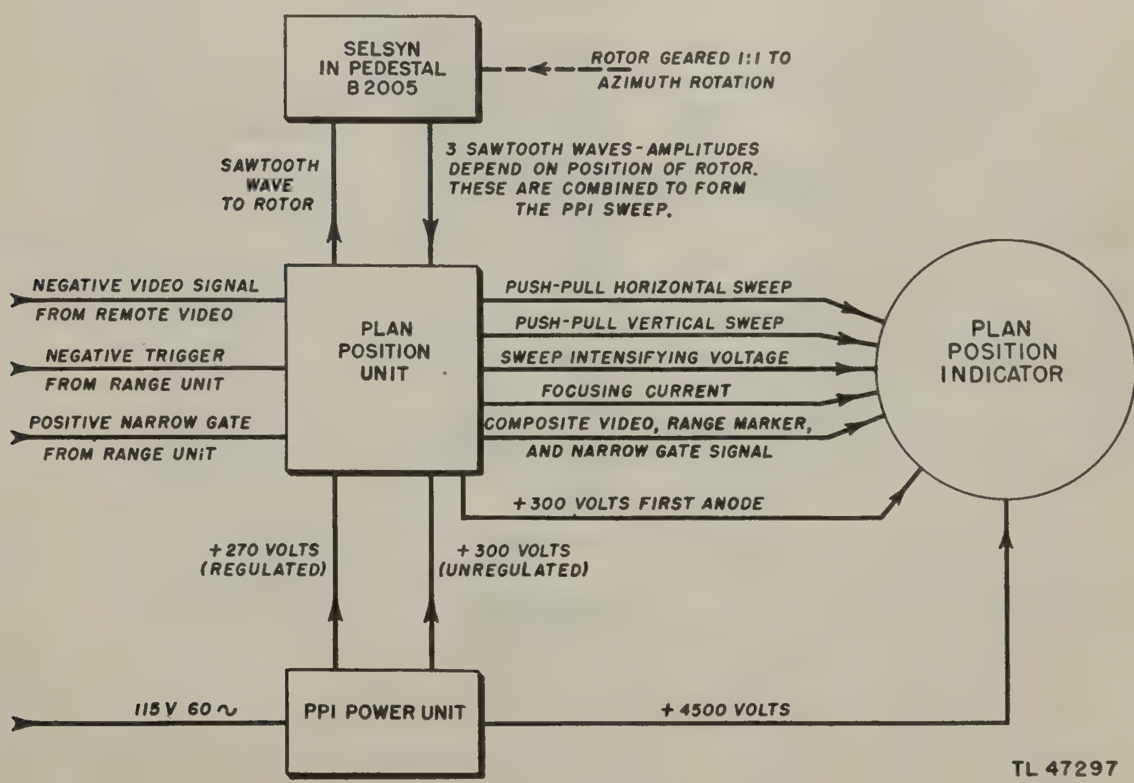

Figure 146. PPI system, simplified block diagram.

operating and control voltages for the PPI scope which gives the PPI scope face the characteristics shown in figure 147. The outputs include:

(*1*) Push-pull horizontal and vertical sweep voltages which move the spot radially outward from the center of the scope, in the same direction the antenna is pointing, producing the timebase sweep line.

(*2*) Composite video, range markers, and narrow gate signal, which produce a bright arc effect on the sweep whenever a signal is received. The range markers inscribe circles at 10,000 yards range; the narrow gate provides a means of showing the operator the range corresponding to the position of the hairlines of the range scopes; and targets show as bright arcs at various points.

(*3*) Sweep intensifying voltage which brightens the scope while the spot moves outward from the center of scope.

(*4*) Focusing current which concentrates the beam of electrons to produce a well defined spot on the screen.

b. PPI Indicator. The output voltages from the PPI unit and selsyn produce a radial sweep on the screen of this scope and provide a visual indication of the target signals, locating them approximately in azimuth and range.

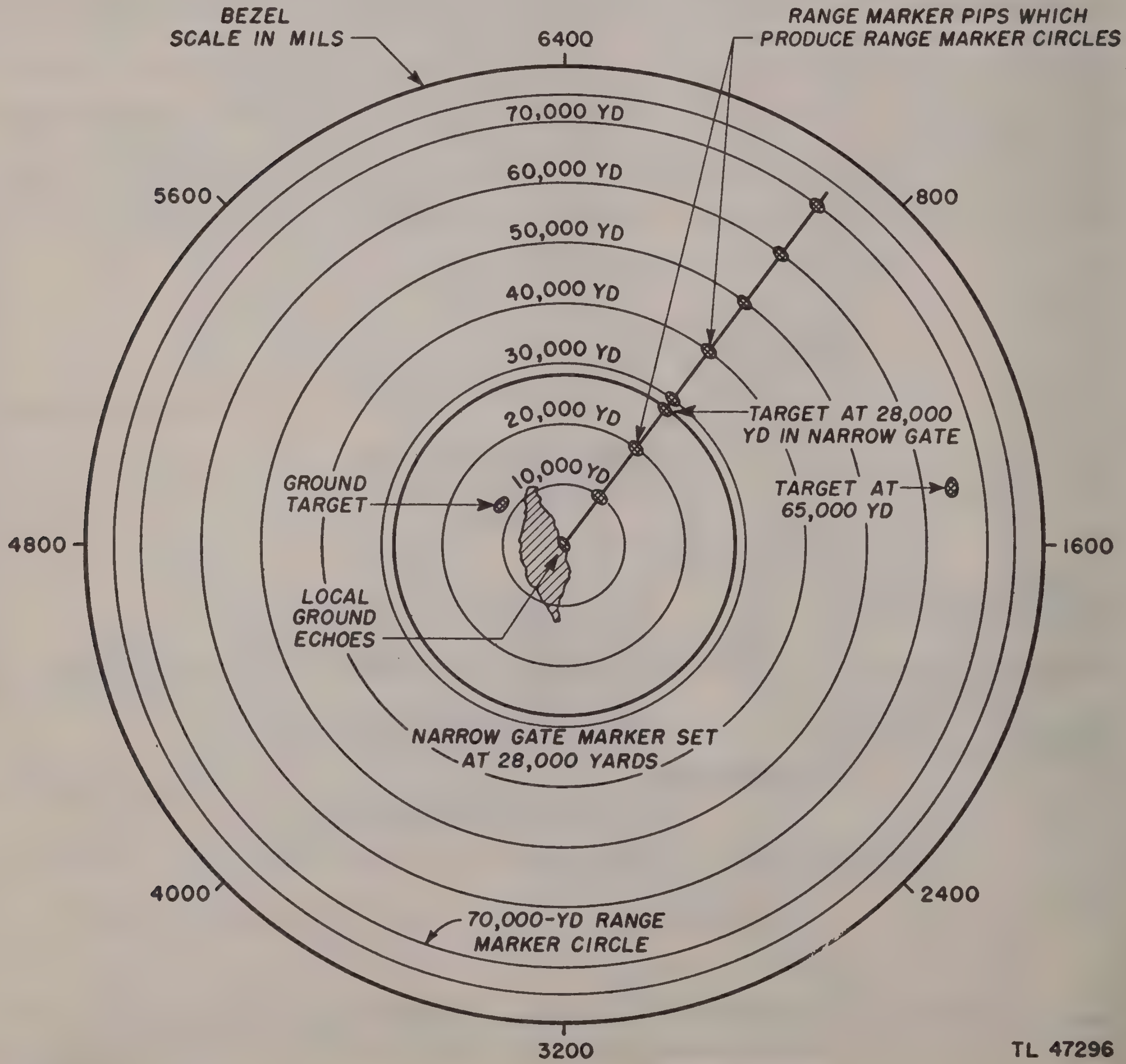

Figure 147. Appearance of PPI scope.

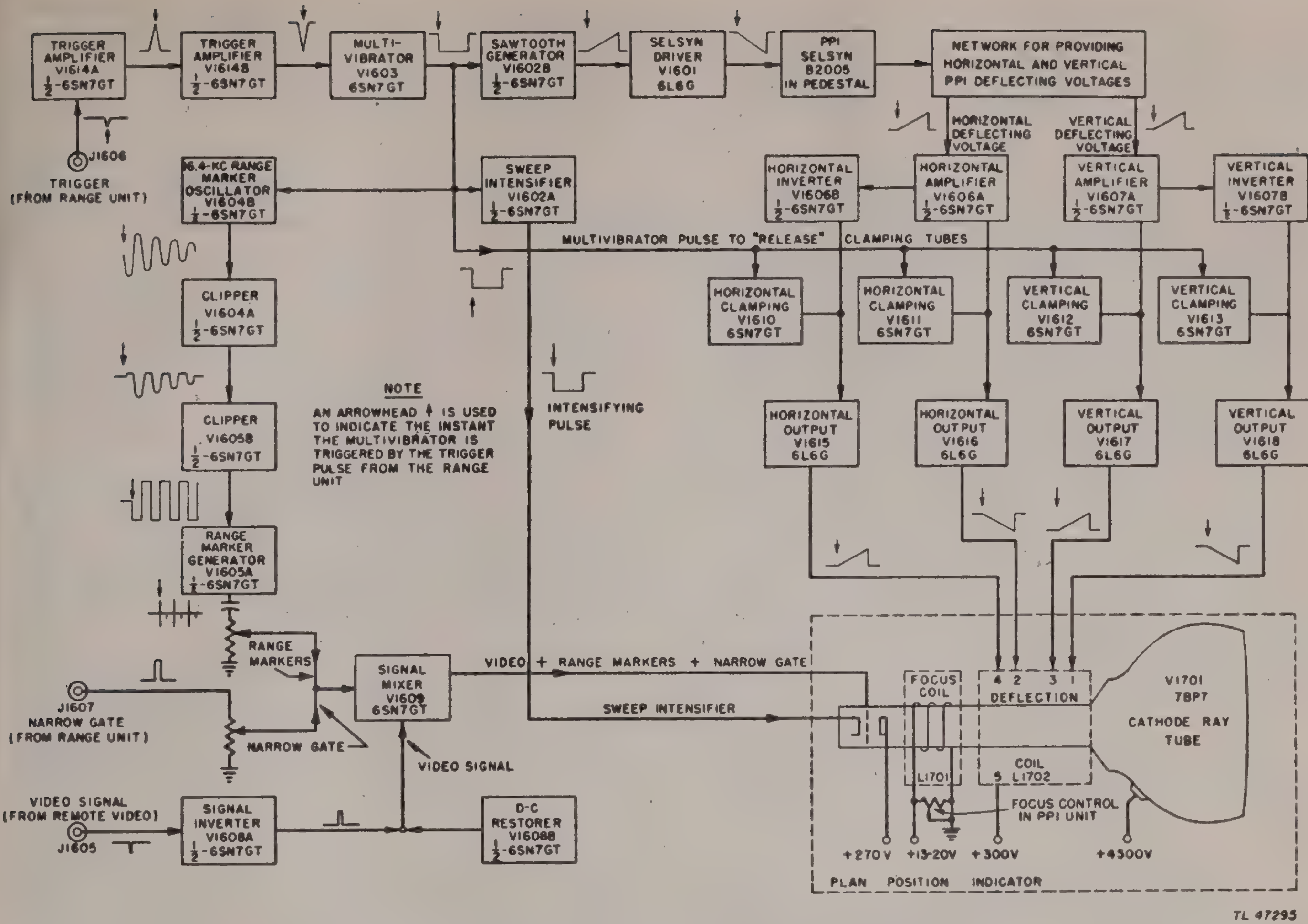

Figure 148. PPI system, complete block diagram.

c. PPI Selsyn. The PPI or transmitting selsyn is geared directly to the antenna with a 1 to 1 gear ratio. As the antenna is rotated in azimuth the rotor of the selsyn is also turned producing a varying control voltage. This output, after amplification by the circuits of the PPI unit provides the horizontal and vertical deflection voltages applied to the coils of the PPI scope.

d. PPI Power Supply. This supply produces the following voltages to operate the various components in the PPI system.

(*1*) 4,500-volt high-voltage supply for the anode of the PPI scope.

(*2*) 300-volt unregulated-plate supply for the PPI unit.

(*3*) 270-volt regulated-plate supply for the PPI unit.

136. COMPLETE BLOCK DIAGRAM.

A complete diagram of the PPI unit is shown in figure 148. Waveforms and direction of the progressing signal are indicated with each block.

a. Trigger Amplifiers V1614. The function of these stages is to amplify the low level negative trigger input from the range unit to a sufficient amplitude to trigger the multivibrator. The signal is amplified and inverted in V1614A and fed to the second amplifier stage V1614B. The second half of tube V1614 further amplifies and inverts the input trigger and feeds it to the multivibrator.

b. Multivibrator V1603. The output of this stage consists of 1.707-kc rectangular waves which are locked by the trigger pulses, and hence are in synchronism with the transmitter. The negative-going portion of the wave triggers four separate circuits; the timebase circuits, the range marker oscillator, the sweep intensifier, and the horizontal and vertical clamping tubes. Two separate square wave outputs are obtained, a 270-microsecond or a 440-microsecond wave depending on range desired on the PPI scope.

c. Timebase Generator.

(*1*) *Saw-tooth Generator V1602B.* The square wave input from the multivibrator cuts off this stage producing a saw-tooth voltage drop across the plate load. This saw-tooth voltage, which develops the PPI sweep, has a duration of 35,000 or 70,000 yards depending on the position of the RANGE SELECTOR switch.

(2) *Selsyn Driver V1601.* This stage amplifies the output of the saw-tooth generator and feeds the rotor of the PPI selsyn in the pedestal.

(3) *PPI Selsyn.* The rotor of this selsyn rotates in synchronism with the antenna, driven by a 1 to 1 gear ratio. The three voltages induced in the stator windings by the current flow through the rotor are fed to a special resistance network which is designed to reduce these three voltages to two separate voltages 90 degrees out-of-phase and of varying magnitude depending on the position of the antenna. One voltage is fed to the horizontal amplifier circuit, the other to the vertical amplifier circuit.

d. Horizontal Amplifier Circuit. The output horizontal deflection voltage from the resistance network is fed to V1606A and V1606B for further amplification and inversion. A push-pull output is obtained from this tube which is fed to the horizontal output amplifiers V1615 and V1616. These two tubes are push-pull power amplifiers which apply the sweep voltage to the horizontal deflection coil (terminals 2 and 4) which is connected across the plates of the two tubes.

e. Vertical Amplifier Circuit. These stages (V1607, V1617, and V1618) function in the same manner as the horizontal amplifier circuit in **d** above. The output is fed to the vertical deflection coil (terminals 1 and 3) which is connected across the plates of V1617 and V1618. The voltages across the vertical and horizontal deflection coils produce the rotating timebase on the PPI scope.

f. Clamping Tubes V1610, V1611, V1612, and V1613. These tubes hold the grids of vertical and horizontal output tubes at a predetermined level so that the sweep always starts from the center of the tube regardless of the amplitude of the sweep voltage.

g. Range Marker Circuit.

(1) *Range Marker Oscillator V604B.* This normally-conducting stage with its associated tuned cathode circuit is shock excited into oscillation when triggered by the negative-going portion of the square wave output from multivibrator V1603. The oscillation is a 16.4-kc damped sine wave.

(2) *Clippers V1604A and V1605B.* These tubes consist of two stages of amplification, which clip the sine wave input from the marker oscillator and produce a 16.4-kc square wave.

(3) *Range Marker Generator V1605A.* This tube produces positive pips from the negative-going input square wave. The timing of these pips is such that the distance between pips corresponds to 10,000 yards range.

h. Signal Inverter V1608A. The function of this tube is to amplify and invert the negative input video signals from the remote video amplifier; so they can be applied to the grid of the PPI tube.

i. D-c Restorer V1608B. This tube restores the d-c component of the video signal, which was lost because of the capacitive coupling, so that all the signal voltages applied to the PPI tube start at the same d-c voltage level.

j. Signal Mixer V1609. This stage is connected as a cathode follower and mixes the narrow gate input, the range marker pips, and the video signal and applies these signals to the grid of the PPI scope as a single output.

k. Sweep Intensifier V1602A. This tube, triggered by multivibrator V1603, unblanks the PPI scope for the duration of the outward sweep and prevents the return trace of the PPI sweep from being visible.

137. CABLING.

The interunit cable connections in the PPI system are shown in figure 149. The PPI power supply furnishes d-c voltages to the PPI unit and PPI indicator through cables numbers 47 and 46, the latter being a special high-voltage cable. Two short cables feed the outputs of the PPI unit to the indicator, one (No. 49) carrying the pulses and the other (No. 48) carrying the sweep and control voltages. The PPI selsyn in the pedestal is connected to the PPI unit through the switch and data panel by cables numbers 10 and 8. Other connections to the PPI unit are made with coaxial lines from the range unit, remote video unit and IFF set.

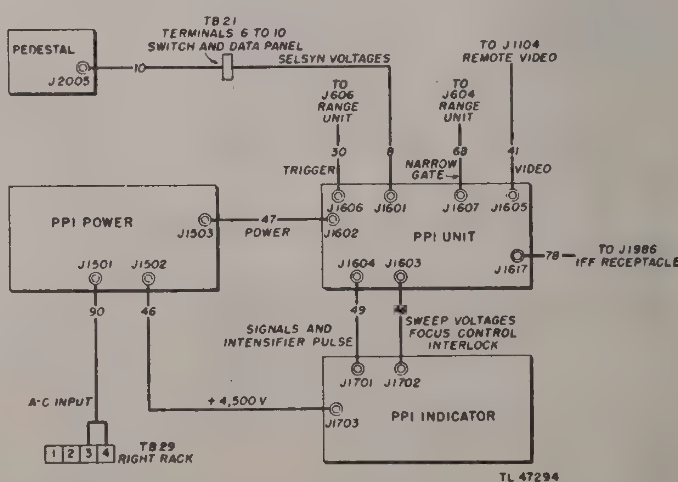

Figure 149. PPI system, cabling diagram.

SECTION II
PLAN POSITION UNIT BC-1058-C

138. INTRODUCTION.

Front and top views showing the location of the PPI stages are shown in figures 150 and 151. A complete schematic diagram is shown in figure 173. The PPI unit contains the following:

a. Necessary circuits to produce the rotating radial timebase for the PPI tube.

b. Circuits to generate and apply the range markers to the PPI tube.

c. Circuits to amplify the video signals from the receiver system and narrow gate pulse, from the range unit and apply these signals to the grid of the PPI tube.

139. TRIGGER AMPLIFIER V1614 (fig. 152).

a. The negative trigger input from the range unit is fed to the grid of V1614A, the first section of the amplifier, through capacitor C1634. Because of the small amplitude of the signal, and the loss of signal strength in the cable it must be amplified to the proper voltage level to trigger the control multivibrator. This stage operates at zero bias and normally is conducting very heavily. When the negative trigger is applied to the grid, the tube is cut off and the resultant plate-voltage rise is coupled as a positive signal to the grid of the second stage through capacitor C1633. This stage is biased approximately at cut-off, the biasing voltage being the drop across resistors R1680, R1667, R1681, and R1683 in the cathode circuit of the output amplifiers. The positive pip causes this section to conduct heavily and the negative amplified pips obtained at the plate of this section are coupled through capacitor C1613 to the grid of V1603A, the control multivibrator of the PPI unit.

b. The bias on both of these stages permits the maximum amplification of the trigger input. The amplifier stages also serve as buffer stages between the multivibrator and the trigger input circuits.

140. MULTIVIBRATOR (fig. 153).

a. Tube V1603 is a conventional, free running, unbalanced multivibrator; the time constant in the grid circuit of V1603A being much shorter than the time constant in the grid circuit of V1603B. As the ratio of the two time constants is approximately 1 to 300, the second stage V1603B remains cut off and the first stage V1603A is conducting heavily until the multivibrator is tripped by the applied trigger.

Figure 150. PPI unit, front view.

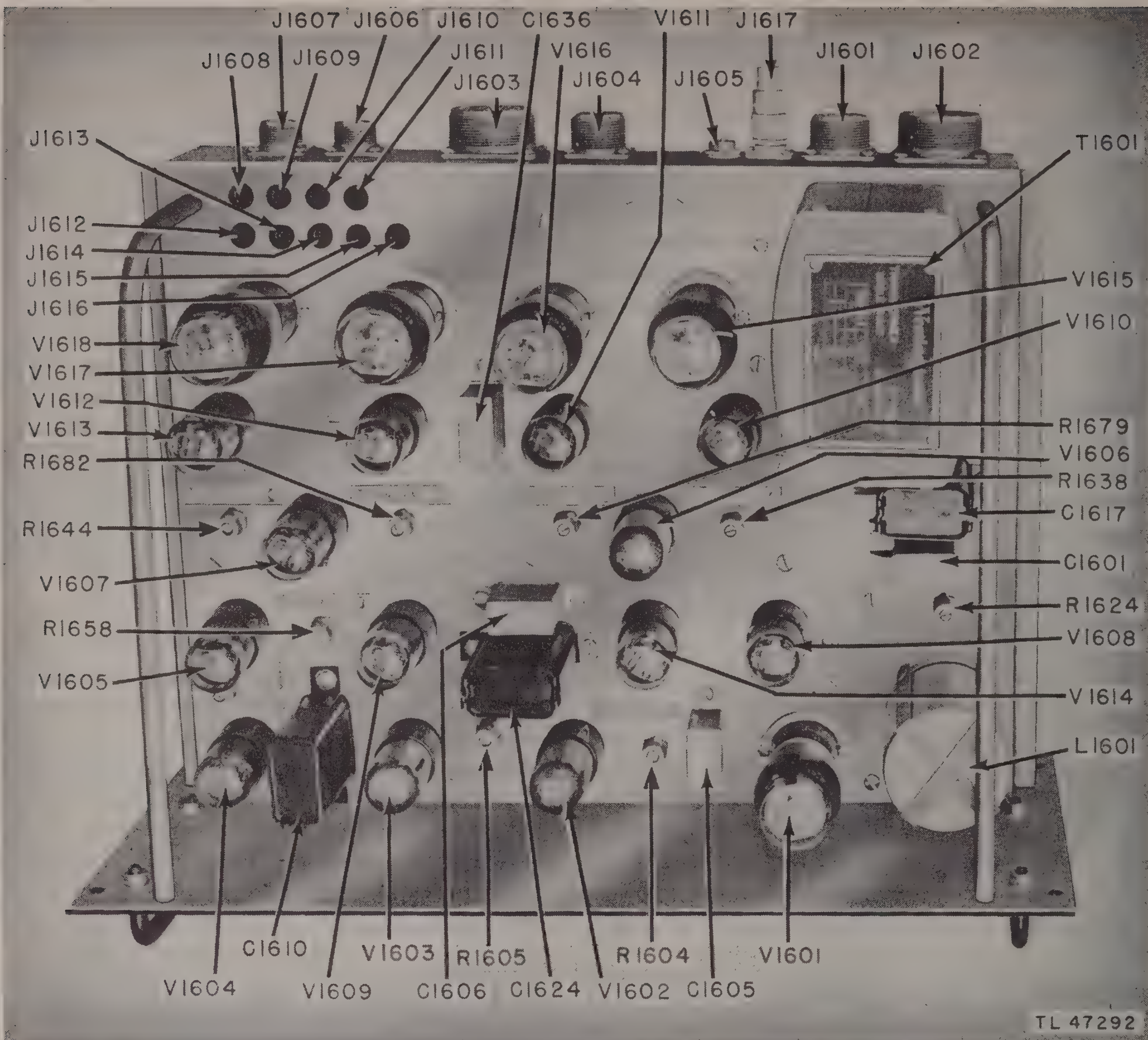

Figure 151. PPI unit, top view.

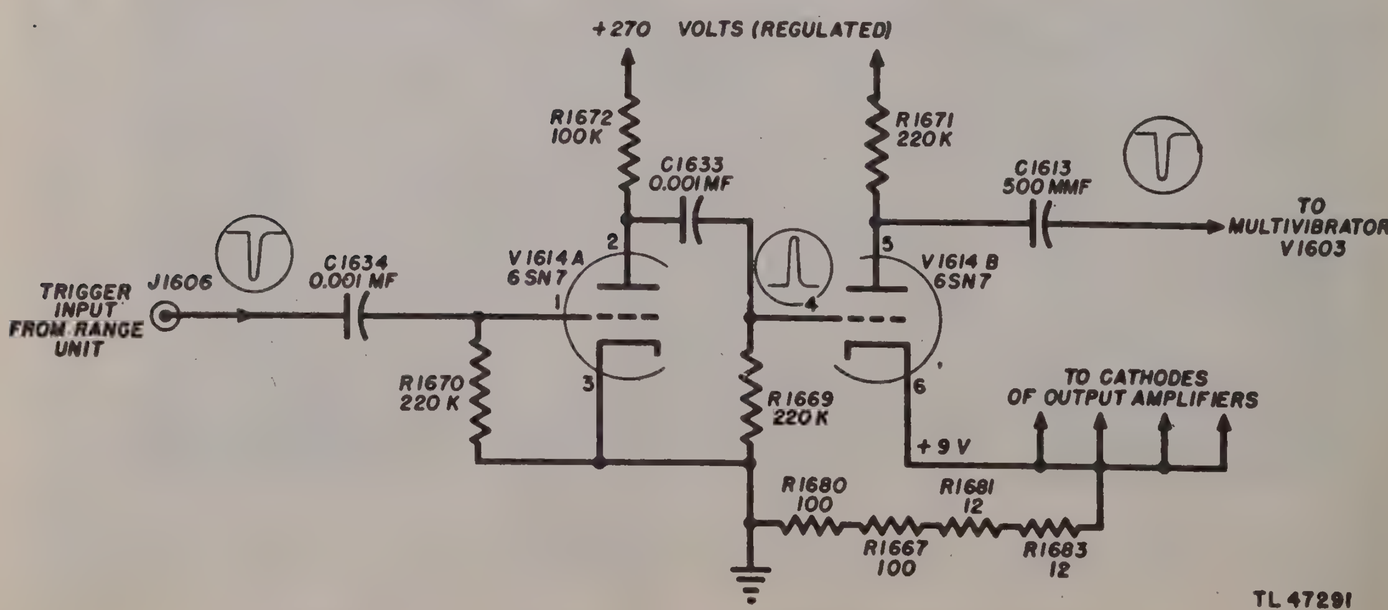

Figure 152. Trigger amplifier, simplified schematic diagram.

b. The negative trigger input from the plate of V1614B is coupled to the grid of the conducting section, V1603A, through capacitor C1613, and instantly drives the grid negative. The section is cut off, and the resultant plate-voltage rise is coupled as a positive-going voltage through capacitor C1611, to the grid of the second section V1603B. This section now starts to conduct heavily and the plate voltage decreases rapidly. In turn this negative-going voltage is coupled back through capacitor C1612 to the first grid, holding V1603A well beyond cut-off. This section remains cut off until the negative charge can leak off capacitor C1612, determined by the R-C time constant formed by capacitor C1612 and resistor R1623 or C1612 and R1623 plus R1624. As the output from the multivibrator is taken from the plate of section V1603B, the width of the rectangular wave depends on the length of time the second section conducts. In turn, this depends on the length of time the first section is held at cut-off.

c. With the RANGE SELECTOR switch S1601 in the 35,000-yard position the time constant is determined by capacitor C1612 and resistor R1623, and is approximately 150 microseconds (500 mmf x 0.3 megohm). The width of the negative portion of the rectangular wave is about 220 microseconds as the 150 microseconds represent only the discharge of 63 percent of

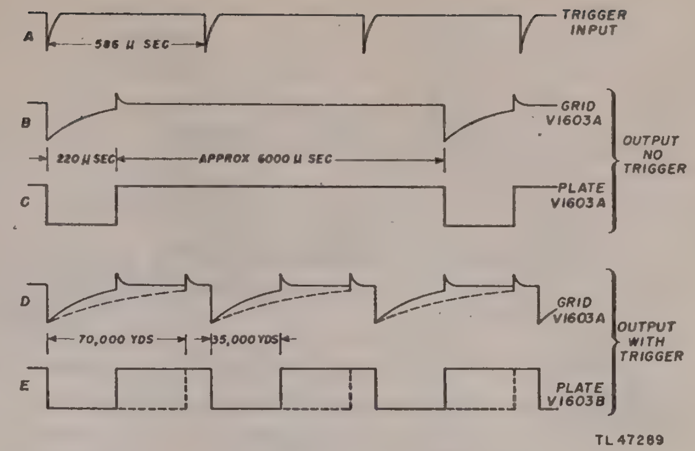

Figure 154. Multivibrator, waveforms.

the charge on the capacitor. The difference between the two is because of the time required for the remainder of the charge to leak off and allow the grid to return to its normal level. With the switch in the 70,000-yard position, resistor R1624 is added to the circuit, doubling the time constant and increasing the width of the wave to about 440 microseconds.

d. The proper operation of the multivibrator also depends on the amplitude and timing of the trigger pulse. Without the proper trigger, the multivibrator runs at a very low repetition rate (fig. 154, B and C) and produces a very faint sweep on the scope. Changes in the value of the R-C time constant circuit produce distorted sweeps, especially at the outer limits of range.

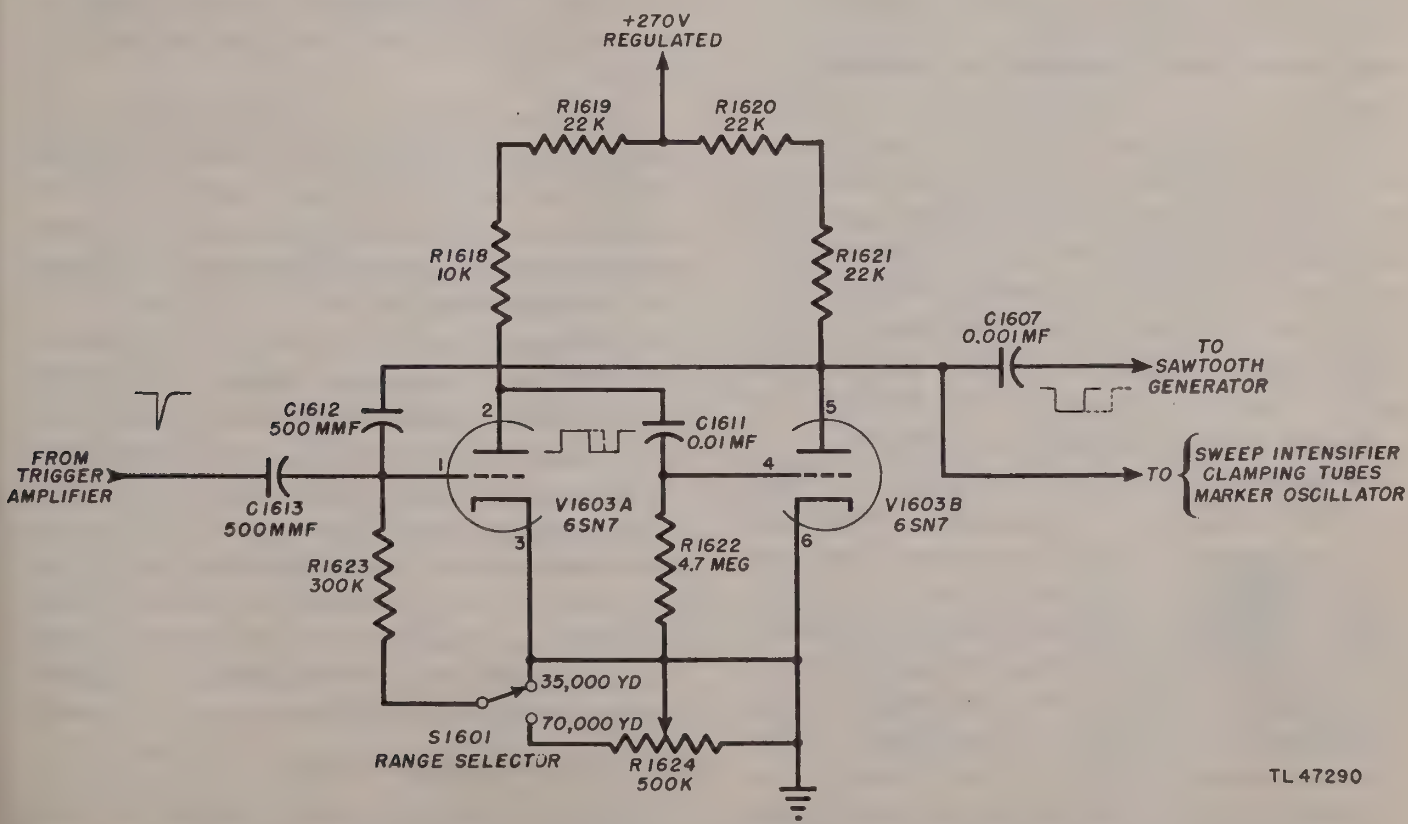

Figure 153. Multivibrator, simplified schematic diagram.

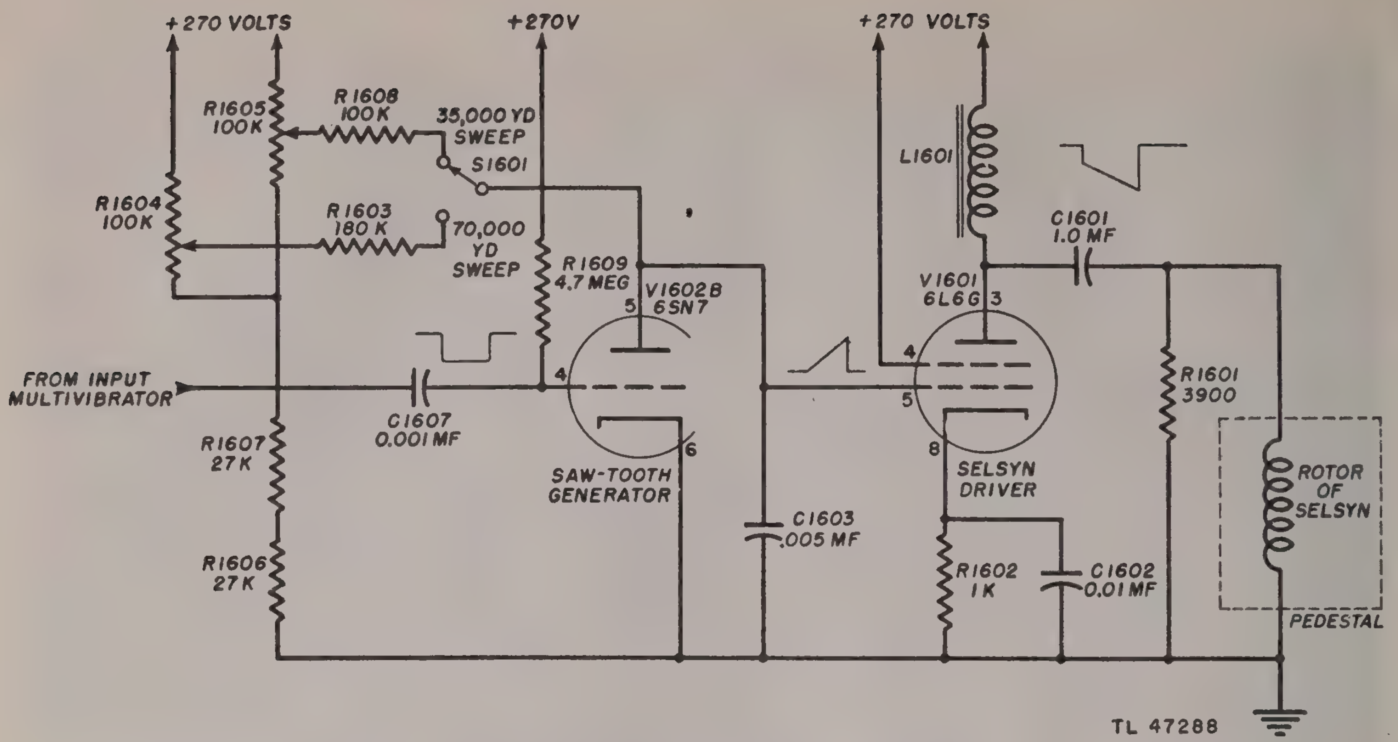

Figure 155. Saw-tooth generator and selsyn driver, simplified schematic diagram.

e. The negative-going rectangular waves produced at the plate of V1603B, figure 154 E, provide timing for four circuits.

(*1*) Saw-tooth sweep generator V1602B.

(*2*) Sweep intensifier V1602A.

(*3*) Clamping tubes V1610, V1611, V1612, and V1613.

(*4*) Range marker oscillator V1604B.

141. SAW-TOOTH GENERATOR V1602B (fig. 155).

a. This stage, used to develop a linear sweep to apply to the selsyn driver, is normally conducting very heavily, the grid being tied to the 270-volt plate supply through resistor R1609, and the cathode being grounded. The potential at the plate is thus low because of the conduction of the tube. Capacitor C1603, in the plate circuit is normally charged to the difference of potential between the plate and ground.

b. When the negative-going wave from V1603B is coupled to the grid of this stage through capacitor C1607, the tube is instantly cut off and the plate tends to rise to the potential determined by the setting of potentiometers R1605 or R1604 depending on the position of the RANGE SELECTOR switch S1601. These potentiometers are part of the voltage-divider network between the +270-volt supply and ground. As the resistance in the plate circuit limits the length of time it takes capacitor C1603 to charge to the plate supply voltage, the voltage at the plate rises in a typical R-C time constant curve. However, the saw-tooth voltage developed across capacitor C1603 is approximately linear, because only a fraction of the charging curve is utilized before the negative-going input wave ends, allowing the stage to conduct again, and driving the plate voltage down to the original level. This positive saw-tooth wave is coupled to the grid of V1601, the selsyn driver stage.

c. One section of the RANGE SELECTOR switch S1601 in the plate circuit of V1602B selects the resistor through which capacitor C1603 charges. On the 35,000-yard range C1603 charges through resistor R1608; on the 70,000-yard range through R1603.

d. The two controls, R1605, the 35,000-YD SWEEP, and R1604, the 70,000-YD SWEEP, are screwdriver adjustments used to vary the sweep length on the two ranges to the required value by determining the maximum voltage to which the capacitor can charge. They provide a fine adjustment of the voltage applied to the plate of the tube. Capacitors C1605 and C1606 (fig. 173) are used to keep the plate supply voltage, determined by the settings of potentiometers R1604 and R1605, at a given potential.

142. SELSYN DRIVER V1601.

a. This stage is a sweep amplifier which develops the sweep current through the rotor of the transmitter selsyn. The linear input

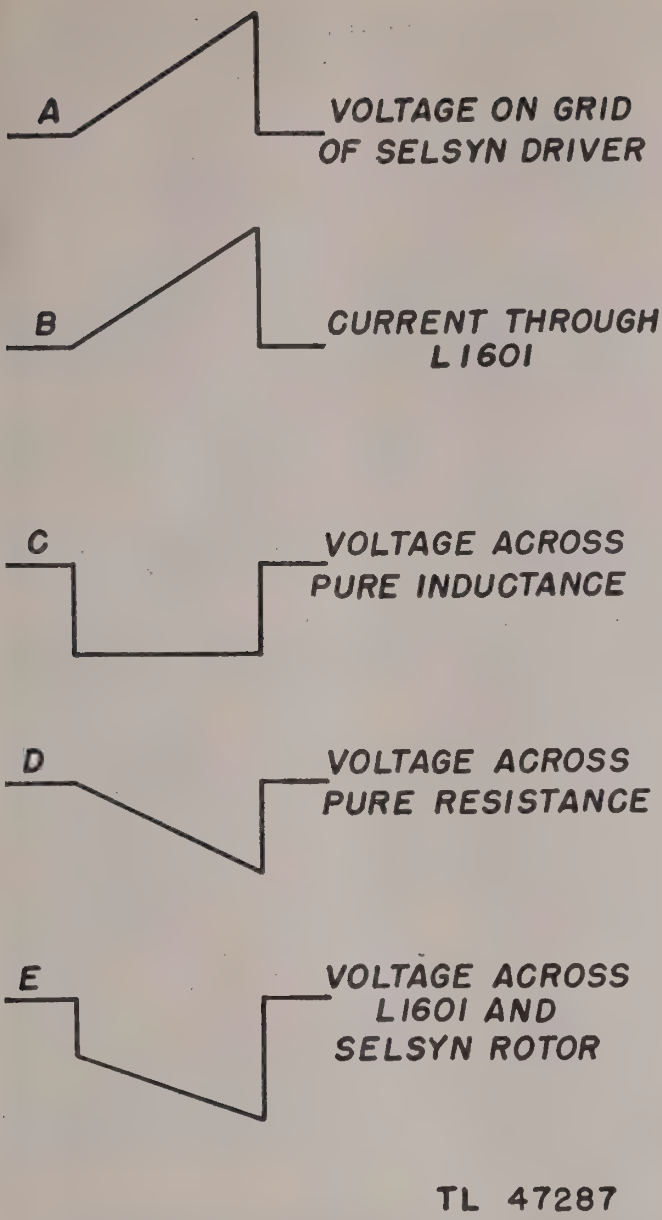

Figure 156. Saw-tooth generator waveforms.

sweep from the saw-tooth generator is coupled directly to the grid of this tube, operating as a class A amplifier. The plate load consists of choke L1601 and is used to produce the required trapezoidal voltage wave necessary to insure a linear saw-tooth current through the rotor coil of the selsyn, figure 156. Because of the associated inductance and resistance of the rotor coil, a trapezoidal wave rather than a linear rise is required for a linear current sweep in the selsyn.

b. When no saw-tooth voltage is applied to the grid of V1601 the current through the inductance is at a constant value and the voltage at the plate of the tube remains constant. When the saw-tooth voltage is applied to the grid the current through the inductance rises linearly (fig. 156B). If the coil L1601 were a pure inductance the voltage drop across the coil would drop instantly and continue at this new value as long as the rate of change of current remains constant because the voltage drop across a coil depends on the rate of change of current. Since there is a certain amount of resistance in the coil, this produces an additional voltage drop depending on the magnitude of the current (fig. 156 D). The voltage across the inductance adds to the voltage drop across the resistance in the coil to produce the necessary trapezoidal voltage wave across the selsyn rotor (fig. 156 E).

143. PPI SELSYN.

a. The PPI selsyn B2005, by means of which the sweep voltages are produced, is the conventional data transmission-type selsyn. It is mounted on the pedestal and positions the PPI sweep in azimuth. The rotor is turned by 1 to 1 gearing and makes one revolution with each revolution of the antenna.

b. The normal rate of antenna rotation is 5 revolutions per minute, or one revolution every 12 seconds. The input to the rotor is the 1.707-kc saw-tooth wave produced by the selsyn driver tube V1601. As the rotor of the PPI selsyn is turned by the antenna, a voltage is induced in each of the stator windings by transformer action. When the rotor is parallel to coil No. 1 (fig. 157) a maximum voltage is induced in this coil and a small but equal voltage is induced in the other two coils. As the rotor is rotated the voltage in coil No. 1 will decrease and the voltage in coil No. 2 will increase. This action continues until the axis of the rotor is at right angles to the No. 1 stator winding, and no voltage is induced. When the rotor passes this point, the induced voltage again builds up to a maximum, but in the opposite direction. Since the stator coils are spaced 120 degrees apart, the maximum voltages in each coil can be represented by vectors E_1, E_2, and E_3 (fig. 158) for the voltages induced in coils No. 1, No. 2, and No. 3, respectively.

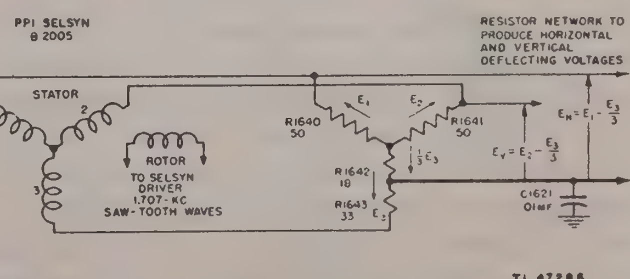

Figure 157. Horizontal and vertical deflection voltages.

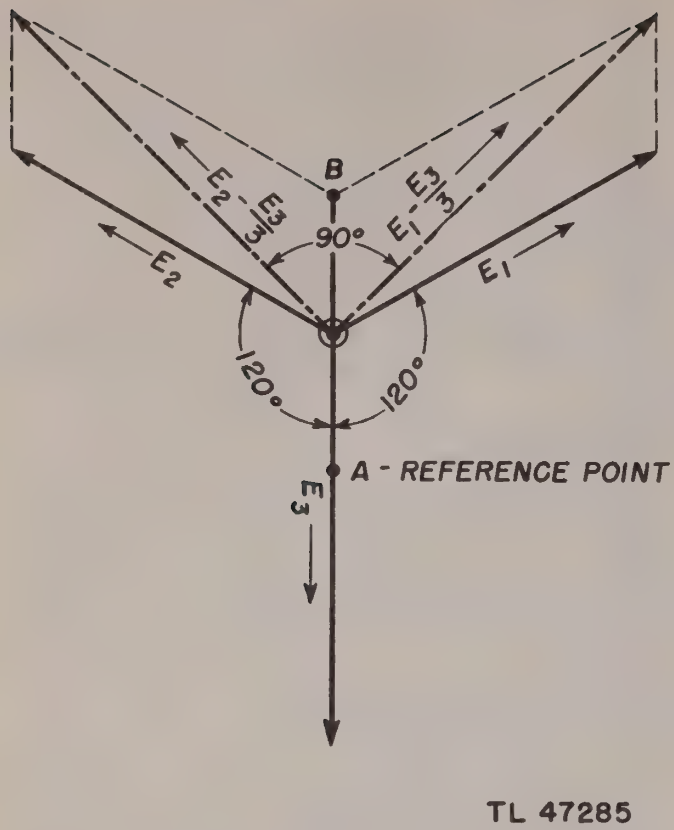

Figure 158. Horizontal and vertical deflection voltages, vector diagram.

c. These voltages are applied across the resistor network (fig. 157) composed of R1640, R1641, R1642, and R1643. This network connected across the selsyn windings converts the three saw-tooth voltages 120 degrees apart in the stators to two voltages 90 degrees out-of-phase. Figure 158 arbitrarily selects one position. Thus the voltage drop across R1642 (fig. 157), which is one-third of the total drop across the combination R1642 and R1643 must be subtracted from the voltage drop across both R1640 or R1641, to produce a difference of potential between the reference point, held at +150 volts, and each of the other two resistors. The voltages cannot be subtracted directly as they differ in phase, and must be subtracted vectorially, which results in the 90-degree phase difference.

d. Figure 158, a vector diagram of the circuit indicates how the two voltages are developed. E_1, E_2, and E_3, represent the three 120° out-of-phase voltages across the resistor network. The reference point A, one-third of line E_3, represents the voltage drop across R1642. A vector difference is obtained by reversing the vector to be subtracted OA and adding this reversed vector, corresponding to line OB, to E_1 and E_2. Develop the parallelogram and the resultant voltages $E_2-\frac{E}{3}$: and $E_1-\frac{E3}{3}$ are obtained. The phase difference of the two voltages is 90 degrees.

e. One of these voltages produces the vertical deflecting sweep, the other produces the horizontal sweep. Figure 159 shows the development of the PPI sweep. At the beginning of the first sweep, time 0, the horizontal field is balanced and there is no horizontal deflection, but at the same moment the vertical field is maximum and the beam is deflected upward towards 1 on the scope. After ¼ revolution, or at time 3, the horizontal field is at a maximum, the vertical field is balanced, and the beam moves toward the right. At time intervals 6 and 9, the operation is repeated, but in the opposite direction as their polarity has changed. For any intermediate point on the circumference of the scope, as at time 1, the beam is positioned by the resultant fields of the horizontal and vertical sweeps. Because the time interval between successive sweeps applied to the rotor is 586 microseconds, corresponding to the 1.707-kc recurrence frequency, the angular separation between sweeps is only about 0.4 mils. Thus the spot moves from the center of the scope to the outside at a linear rate and returns to the center very rapidly. It then repeats the same motion but this time in a direction which differs from the preceding sweep by about 0.4 mils. In this way, the sweep covers the entire face of the scope.

144. HORIZONTAL DEFLECTION CIRCUIT.

a. Horizontal Amplifier Inverter (fig. 160).

(*1*) This stage consists of an amplifier inverter circuit, designed to provide a push-pull output voltage to feed the amplifier stages. Normally section V1606A is conducting as the grid is tapped to approximately 150 volts at the voltage divider R1648 and R1652 (fig. 173), but the cathode bias developed across resistors R1633 to R1635 limits the current flow so as to operate the tube class A on the linear portion of the characteristic curve. The self bias action prevents grid current flow as the cathode follows up to a voltage slightly more positive than the grid. The saw-tooth voltages applied to V1606B from resistor R1640 varies sinusoidally in magnitude (fig. 159C) and alternately cause the section to conduct more and then less, although still operating at class A. This arrangement permits amplification of either the positive-going or negative-going sweep without distortion.

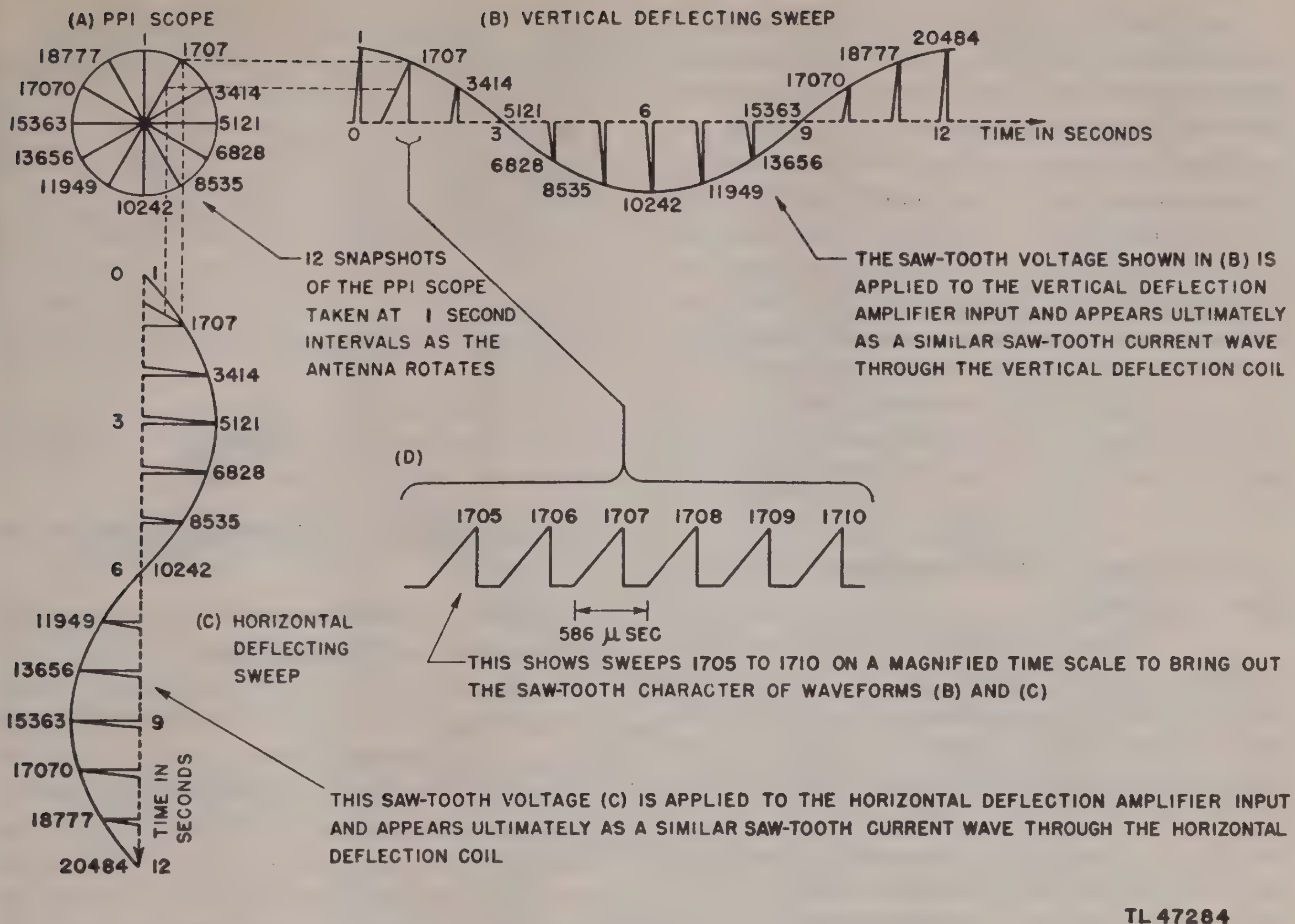

Figure 159. Formation of PPI sweep.

(*2*) When a positive-going sweep is applied to the grid of V1606B, the section conducts more heavily and the voltage drop across R1638, the plate load resistor, couples a negative voltage to the grid of the output amplifier V1615 through capacitor C1628. At the same time, the increase of current through the cathode resistors R1633 through R1635 increases the bias on V1606A. The current flow decreases in this section, causing the voltage at the junction of R1636 and R1637 to rise and a positive voltage is coupled to the grid of the output amplifier V1616 through capacitor C1626.

(*3*) In order that the signals produced at the plate be equal to each other, it is necessary that the common cathode resistor be large. With the circuit functioning properly, the signal at the cathode is only slightly greater than one-half of the signal applied to the grid of V1606B, and the signal at the plate of J1606A is only slightly less than the signal at the first plate. The over-all effect at the plates is that the voltage at the plate of V1606B decreases at the same time and at the same rate as the voltage at the plate of V1606A rises, producing a push-pull effect. As the input sweep signal decreases to zero and then decreases further in a negative direction (following the sine wave pattern) the outputs of the two sections change in amplitude and polarity.

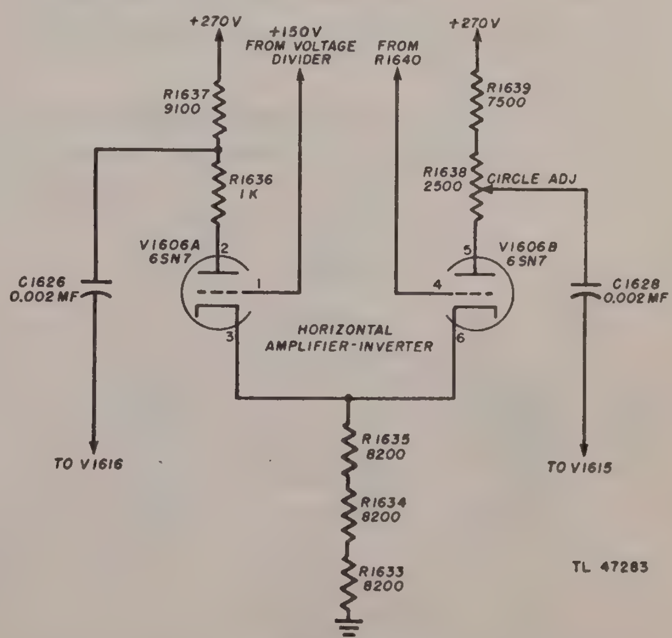

Figure 160. Horizontal amplifier inverter, simplified schematic diagram.

(*4*) The CIRCLE ADJUST potentiometer R1638 in the plate circuit of section V1606B provides sufficient range of adjustment to compensate for variations in the output caused by changing tube characteristics and resistor values. It is a screwdriver adjustment located on top of the chassis and should be set so that the range markers inscribe circles on the scope when the control switch is set for PPI SCAN. A limited amount of sweep amplitude adjustment is possible but it affects both the 35,000-yard sweep and the 70,000-yard sweep and hence it may be necessary to adjust the sweep-amplitude controls after using the CIRCLE ADJUST control.

b. Horizontal Output Amplifiers V1615 and V1616 (fig. 161).

(*1*) The push-pull output of the horizontal amplifier inverter V1606 is fed to the push-pull beam power output amplifier tubes V1615 and V1616. The tubes are normally conducting, the cathode bias voltage holding the tubes at class A operation. The plate voltage is supplied by the 300-volt center tap connection of the horizontal deflection coil connected across the plates of V1615 and V1616. The 180 degrees out-of-phase input signals are coupled to the two tubes through capacitors C1626 and C1628 and the polarities of the push-pull output signals produce the required direction of current flow through the deflection coil.

(*2*) Shunt resistors R1676 and R1688 connected between the two plates act as a damping resistance across the deflection coil to prevent the production of oscillation which would distort the sweep.

(*3*) The use of unbypassed cathode resistors R1677 and R1673 tend to stabilize the output,

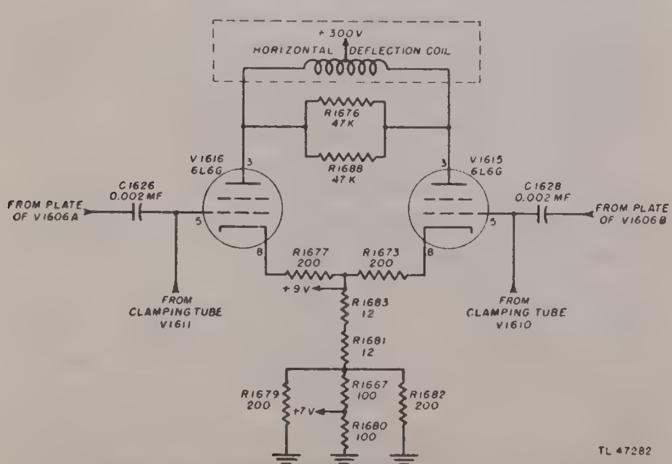

Figure 161. Output amplifiers.

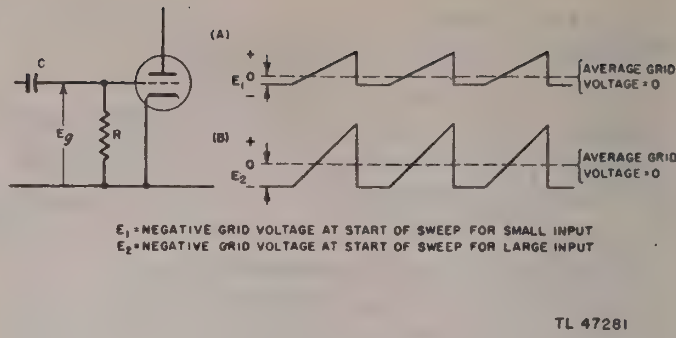

Figure 162. Loss of baseline with R-C coupling.

reduce distortion, and compensate for difference of characteristics of various 6L6 tubes.

145. HORIZONTAL CLAMPING TUBES V1610 AND V1611.

a. These two tubes take the places of the grid resistors usually employed in the grid circuit of an amplifier. In order for the PPI sweep to start from the center each time the sweep begins, it is necessary that the current through all four of the output tubes be equal when no sweep voltage is applied so that the spot is positioned correctly at the center of the PPI screen. Since the amplitude and polarity of both the horizontal and vertical sweep components vary with the position of the antenna, this cannot be accomplished using conventional R-C coupling. With R-C coupling, shown in figure 162, the grid voltage at the start of the sweep would equal the average value of the saw-tooth wave. As this value is constantly changing, the tubes would carry unequal currents and the sweep would not center properly.

b. To make certain that each sweep does start from the center of the scope, the clamping tubes are employed. Each of these tubes consists of two triode sections, connected in series between a 6-volt point (one side of resistor R1680 which is part of the cathode resistor network of the output amplifier tubes) and a 140-point (the plate of V1611A). Normally both sections are conducting, and the junction at the plate of V1611B and the cathode of V1611A provides a +14-volt tap similar to a voltage-divider network, which keeps the output grid at this constant voltage. The saw-tooth voltage is applied to the junction at the same time as to the output amplifiers, and to this junction is connected the control grid of the amplifier being clamped, tube V1616. Tube V1610 is connected in a similar manner to the output amplifier V1615.

c. When the multivibrator triggers the sweep circuit, developing the output current fed to the deflection coil, the same negative gate is coupled to the grids of V1611A and V1611B, through capacitor C1627. The grids are driven negative and both sections of the tube are cut off. During this cut-off period with no current flow, the junction of the plate and cathode are effectively isolated from the circuit. In turn, the grid of V1616 which was at +14 volts is unclamped and the tube can follow the saw-tooth input from the amplifier inverter stage.

d. At the end of the negative gate both clamping sections return to their original condition. The sections start to conduct again, and the potential at the plate and cathode junction settles down to about +14 volts and holds or clamps the control grid of V1616 at 14 volts until

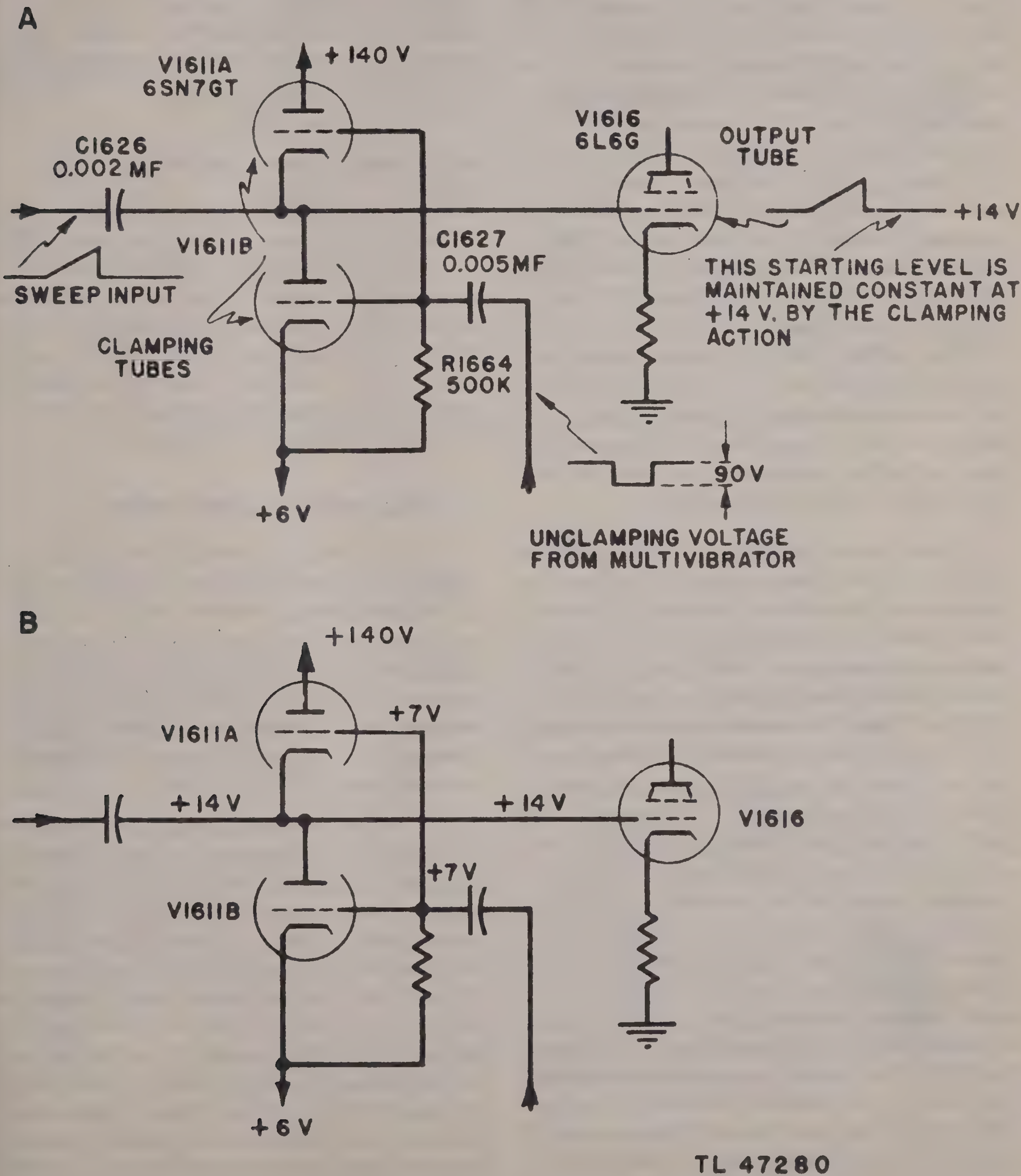

Figure 163. Clamping circuit, simplified schematic diagram.

the start of the next sweep. At the end of each sweep the same process is repeated, the grid of V1616 being clamped to await the start of the next saw tooth. Since the same arrangement is used to clamp the control grids of the other three output tubes to the same voltage, the deflection of the beam is zero at the start of the sweep and the trace starts from the center of the scope.

e. The value of the clamping voltage (+14 volts) is determined by the characteristics of the two sections. As they comprise a series voltage-divider network, both tubes must carry the same current. One section operates with high plate voltage (140 volts) and high grid bias (+7 volts) and draws the same amount of current as the second section which operates at a low plate voltage (+14 volts) and a slightly positive grid bias. Thus the junction must settle down to the relatively low voltage of 14 volts. This potential represents the optimum value, as a higher voltage at the junction would put excessive bias on the first section and prevent the tubes from drawing the same current. Any change in this voltage tends to increase the plate current of one section and decrease the plate current of the other section.

f. Even though the grids of the output tubes are held at the same potential, variations in resistors and tubes make it necessary to provide some means for adjusting the centering of the sweep. Potentiometers R1679, the horizontal CENTER ADJ and R1682, the vertical CENTER ADJ (fig. 173) accomplish this by allowing the clamping voltage on one of the horizontal output tubes and one of the vertical output tubes to be varied slightly. The cathode and grid of one horizontal clamping tube V1611 and one vertical clamping tube V1613 is fixed at the potential existing at the junction of R1667 and R1680, but by varying the CENTER ADJ controls, the cathode and grid potential of the other horizontal clamping tube V1610 and the other vertical clamping tube V1612 can be changed. Any change would thus cause V1610 and V1612 to conduct more or less and change the voltage at the plate and cathode junction. This changes the outputs of V1615 and V1617 and moves the scope beam both horizontally and vertically.

146. VERTICAL DEFLECTION CIRCUIT.

a. This circuit consists of:

(*1*) The vertical amplifier inverter stage, V1617, and V1618.

(*2*) The vertical output amplifier tubes V1617 and V1618.

(*3*) The clamping tubes V1612 and V1613.

b. These stages are identical with the corresponding horizontal deflection stages. They produce the required voltages to operate the vertical sweep properly.

147. RANGE MARKER CIRCUIT (fig. 164).

For estimating slant range to a target on the PPI scope, it is advantageous to have some form of a scale to locate the target approximately. As a calibrated scale on the face of the scope would be inaccurate because of the non-linearity of the sweep, and the two different sweep ranges, an electronic range marker circuit is used. This circuit develops rings around the face of the scope at intervals of 10,000 yards.

a. Range Marker Oscillator V1604B.

(*1*) This stage is normally conducting very heavily as the grid is tied to the plate supply (+140 volts) through resistor R1625. The cathode circuit consists of coil L1602 and capacitor C1615 forming a tuned circuit whose natural frequency is 16.4 kc. This frequency is chosen because the 61- microsecond interval between successive peaks of a 16.4-kc wave corresponds to a slant range of 10,000 yards.

(*2*) When the negative-going wave from the multivibrator is coupled to the grid through capacitor C1614, the tube is instantly cut off, and the energy stored in the coil oscillates at the natural frequency. Although these oscillations are damped because of the resistance of the coil itself and the current flow through the coil when the grid of V1604A is driven positive by the positive half cycles of the oscillations, their duration is longer than the duration of the negative-going pulse. When the negative input ends abruptly, the tube reverts instantly to its original conducting state cutting off the oscillations because of the low tube resistance

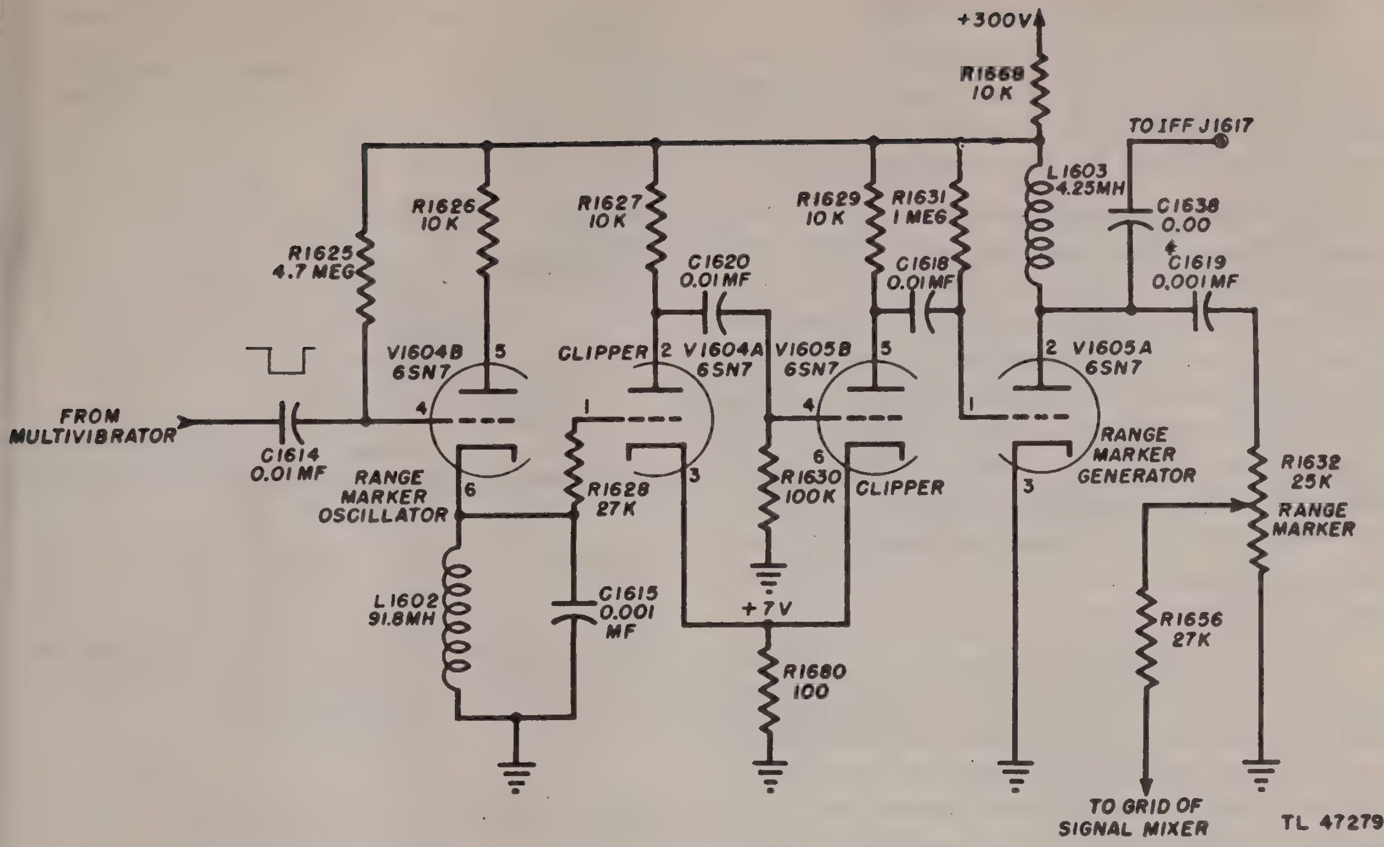

Figure 164. Range marker circuit, simplified schematic diagram.

now shunted across the tuned circuit. This circuit is shocked into oscillation at the instant the sweep circuit is triggered, assuring accurate placement of the pips on the sweep of the PPI. Waveforms of the entire range marker circuit are shown in figure 165.

b. First Clipper Stage V1604A.

(*1*) The damped waveform across the 16.4-kc tuned circuit is fed to the grid of this stage through resistor R1628. The tube is normally conducting only slightly as it is almost biased to cut-off by the voltage drop (+7 volts) across R1680, applied to the cathode, and the plate voltage is thus relatively high.

(*2*) When the oscillator circuit is shocked into oscillation, the negative half cycle applied to the grid drives the tube well beyond cut-off. but as the plate voltage was nearly at its normal value, the positive rise coupled to the grid of the second clipper stage V1605B is slight. However, on the positive half cycle as the grid is driven positive and draws current, the tube is driven to saturation. The plate voltage drops to a minimum, and this negative-going voltage is coupled through capacitor C1620 to the grid of the second clipper (fig. 165).

c. Second Clipper Stage V1605B.

(*1*) This stage further amplifies and clips the voltage waveforms coupled to the grid. The tube is at the same operating point as the first clipper stage.

(*2*) When the positive-going square wave is coupled to this section, although of relatively low amplitude, it is more than enough to overcome the cathode bias on the stage, and it drives the tube to saturation. The resultant plate-voltage drop is clipped, squared, and coupled to the grid of V1605A through capacitor C1618. The negative input wave on the alternate half cycle drives the stage beyond cut-off and the positive rise in plate voltage is coupled to the grid of V1605A.

d. Range Marker Generator V1605A.

(*1*) This tube is normally conducting heavily, the grid being tied to B+ through resistor R1631. The cathode is grounded and the plate load consists of the 4.25-millihenry choke L1603.

(*2*) When, the negative-going edge of the square wave is coupled to the grid, it drives the tube beyond cut-off instantly, and as a result a large positive voltage pip is induced across the choke. This positive-going pip is coupled to the grid of the signal mixer tube V1609B through capacitor C1619, with the RANGE MARKER potentiometer R1632, a screwdriver adjustment controlling the amplitude of the applied signal. The stage is held at saturation to develop the maximum amount of voltage swing when the tube is cut off.

(*3*) The waveforms shown in figure 165, bring out the essential action taking place in the range marker circuit. The actual waveforms are not as clean cut as shown in this figure especially those of the marker generator. This is because the choke is shocked into a high-frequency oscillation, which although damped out after one or two cycles, does distort the waveshape. The negative pips on the range marker waveform have no important effect because they simply drive the PPI grid further beyond cut-off.

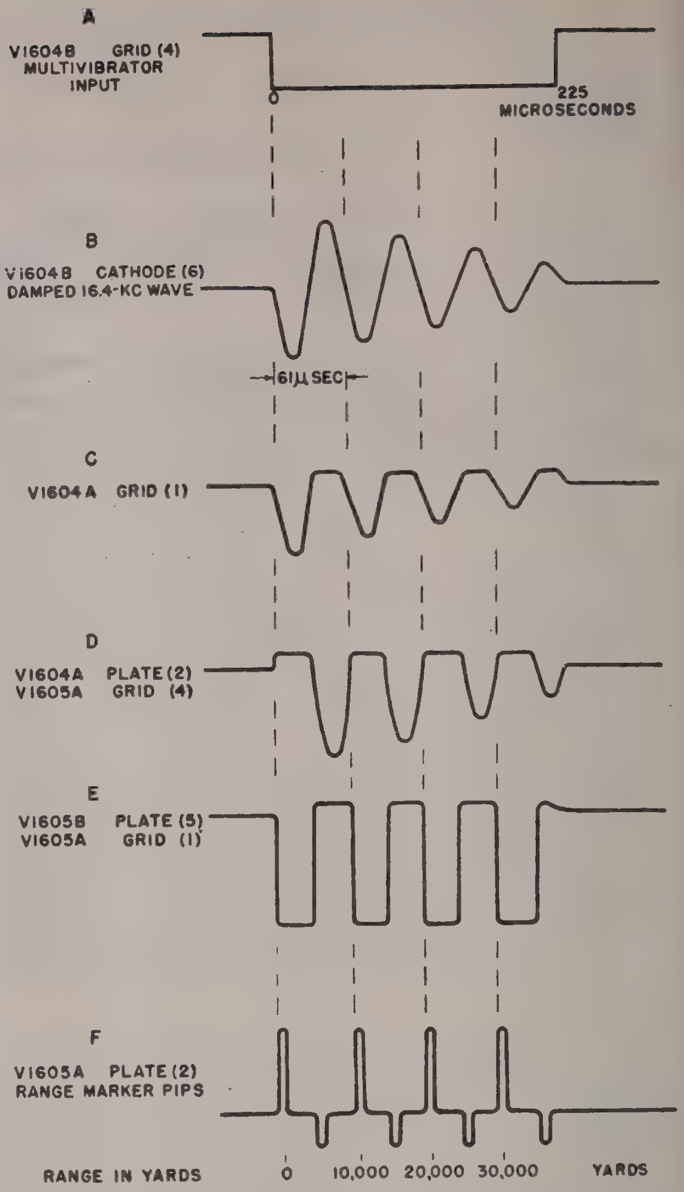

Figure 165. Range marker circuit, waveforms.

148. SIGNAL INVERTER V1608A (fig. 166).

a. This stage is simply an inverter to change the negative input pulses (received echoes) from the remote video unit, to positive pulses. The range unit requires negative pulses for proper operation; so the output of the remote video amplifier is made negative but as the PPI unit requires positive pulses this inverter stage is necessary.

b. The tube is normally conducting heavily as the grid and cathode are grounded, and the tube operates with zero bias. The negative input pulses are coupled to the grid through capacitor C1635 causing a decrease in conduction and a rise in the plate voltage. This positive-going voltage is coupled to one of the two inputs to the signal mixer stage V1609, through capacitor C1622. Capacitor C1624 is used as a bypass to stabilize the plate supply voltage.

149. D-C RESTORER V1608B.

a. This stage is used as a d-c restorer, the control grid and plate being tied together so that it functions as a diode. The purpose of the restorer is to maintain the grid of the signal mixer at ground potential between each successive signal. This has the desirable effect of maintaining the noise at a fairly constant level and making use of the full amplitude of weak signals to drive the grid of the PPI above ground (fig. 167).

b. Without the d-c restorer, when the negative input signal leaves the grid of the inverter and the plate voltage drops to the normal conduction level, the capacitor C1622 discharges and drives the grid of V1609A negative. With the d-c restorer in the circuit when C1622 discharges it tends to drive not only the grid of V1609 negative, but also the cathode of V1608B. This causes V1608B to conduct, and C1622 is im-

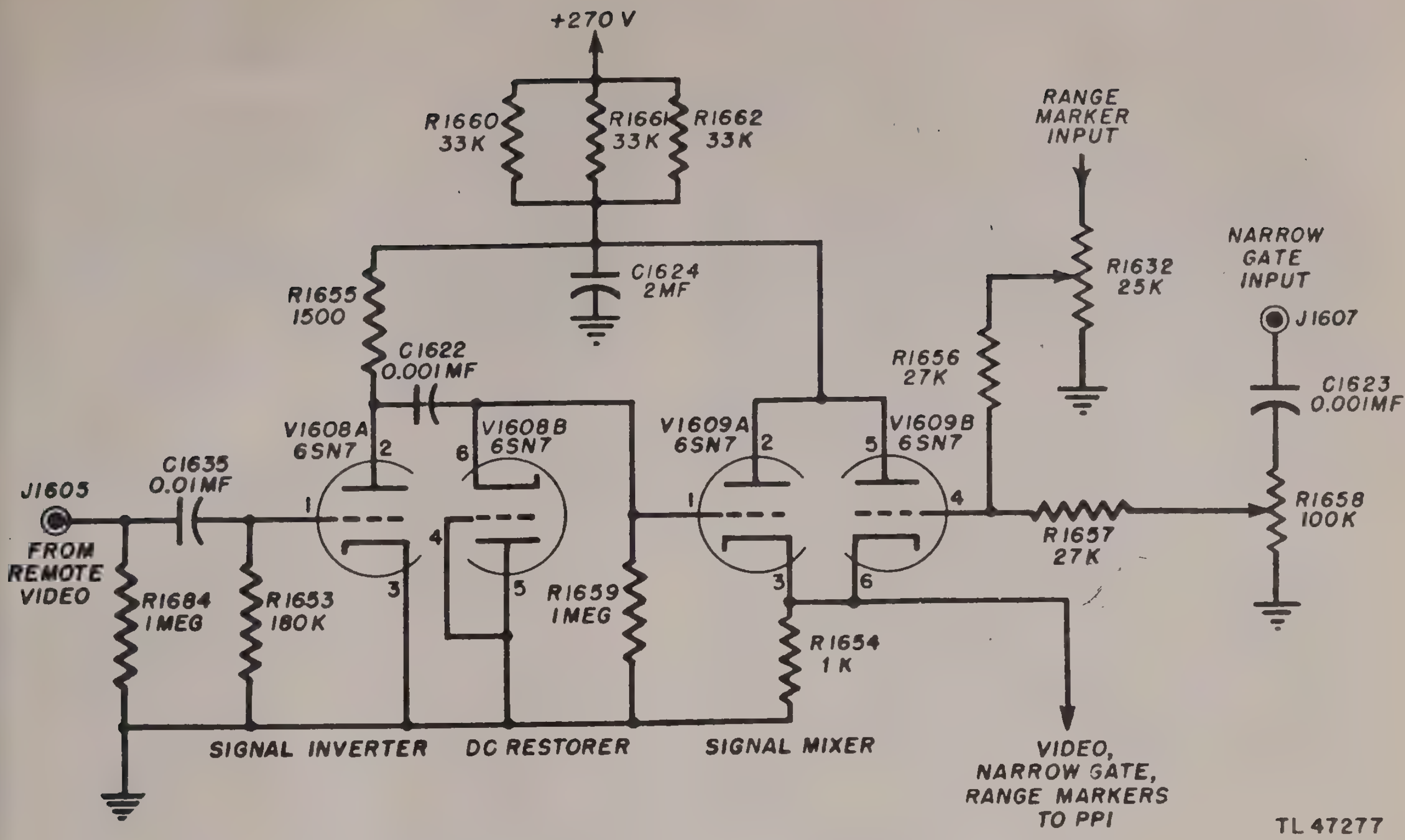

Figure 166. Signal inverter, restorer and mixer, simplified schematic diagram.

mediately discharged through V1608B. Thus the voltage at the grid of V1609A would vary only above ground and would never acquire an appreciable negative charge.

150. SIGNAL MIXER V1609.

a. The signal mixer tube is a double triode used as a dual grid cathode follower with a common cathode load. The video signal is applied to the grid of V1609A while the narrow gate and range marker circuits are fed to the grid of V1609B. As a result of the common cathode resistor R1654, a composite signal voltage is developed which includes the video pips, the narrow gate pips and the range marker pips. These are all positive pips and are applied to the control grid of the PPI scope.

b. The amplitude of the range pips is controlled by the RANGE MARKER potentiometer R1632. The amplitude of the narrow gate is controlled by the NARROW GATE potentiometer R1658. These adjustments can be made independently of one another because of the isolating resistors R1656 and R1657.

151. PPI SWEEP INTENSIFIER V1602A.

a. This stage is used to provide an unblanking voltage for the PPI scope during the interval that the sweep voltages are applied to the scope. The stage is conducting heavily between negative gates, the grid being tied to B+ through resistor R1612 (fig. 173). The d-c level of the cathode is determined by the setting of the INTENSITY control R1614, which is part of the voltage-divider network between the 270-volt plate supply and ground. When conducting, the positive potential developed at the

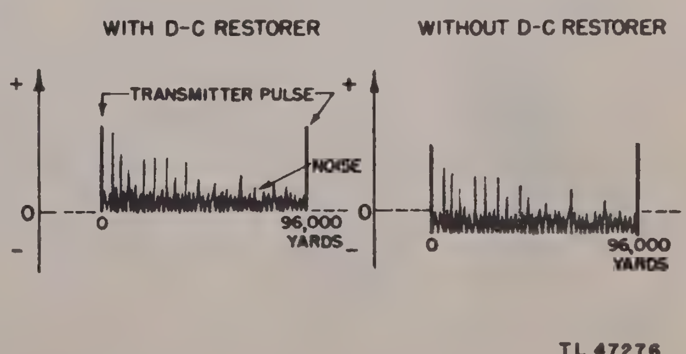

Figure 167. Action of d-c restorer.

cathode across resistors R1616 and R1614 and applied to the cathode of the PPI is sufficiently high to cut off the beam. The negative gate input coupled to the grid through capacitor C1608 cuts off the tube, and the potential at the cathode decreases to the predetermined d-c level which allows the cathode-ray tube to conduct. At the end of the gate, the tube again conducts, the cathode voltage rises and the PPI is again blanked. The unblanking interval is the same as the interval occupied by the sweep voltage.

b. The setting of the INTENSITY control R1614, varies the intensity of the trace by controlling both the positive bias level on the cathode-ray tube when tube V1602A is conducting, and the constant d-c level when V1602A is cut off.

SECTION III

PPI INDICATOR BC-1092-C

152. GENERAL.

A complete schematic diagram of the PPI indicator is shown in figure 174. The function of the indicator is to present visually the plan position data furnished by the PPI unit. The following are the major components contained in the unit:

a. The PPI scope V1701.

b. The horizontal and vertical deflection coil assembly L1702.

c. The focus coil assembly L1701.

153. PPI INDICATOR TUBE.

a. The cathode-ray indicator tube for the PPI is a type 7BP7 tube, using magnetic deflection and focusing. The characteristics of the tube are such that it requires a first anode voltage of +300 volts and a second anode voltage of +4,500 volts for normal operation. The second anode is a thin coating of graphite deposited on the inner surface of the evacuated tube. This graphite coating extends from a point about ½ inch back of the fluorescent screen to a point just ahead of the deflection coil.

b. The beam-forming portion, or electron-gun structure is of conventional design, consisting of a cathode emitter, a control grid for regulating the intensity of the beam, and a beam-forming first anode which provides the initial acceleration for the electrons leaving the cathode. Once the beam leaves the electron-gun structure, the electrons are accelerated toward the screen by the action of the +4,500 volts on the second anode. Before reaching the screen the beam passes through the two coils which focus and deflect it. Both focus and deflection coils are stationary. The tube connections are all brought to the base pin connections with the exception of the one for the second anode. The second anode voltage connection is made to a pin located on the bulb of the PPI tube, that connects with the graphite coating.

c. A transparent plastic cover plate mounted over the face of the scope protects the fragile PPI tube. In addition this cover plate has azimuth markings (0 to 6,400 mils) engraved around its outer circumference. These markings are used to determine the azimuth bearing of targets.

154. FOCUSING.

a. The current through the focusing coil L1701 produces a strong magnetic field parallel to the axis of the tube. The electrons which leave the cathode and move along the axis of the tube are not affected by the magnetic field as they move parallel with it. However, those electrons which are diverging from the axis as they leave the cathode enter the magnetic field at an angle, and are deflected in a twisting corkscrew motion which eventually brings them in alignment with the axis. The greater the angle made by the beam with the magnetic field, the greater the action of the field on the beam.

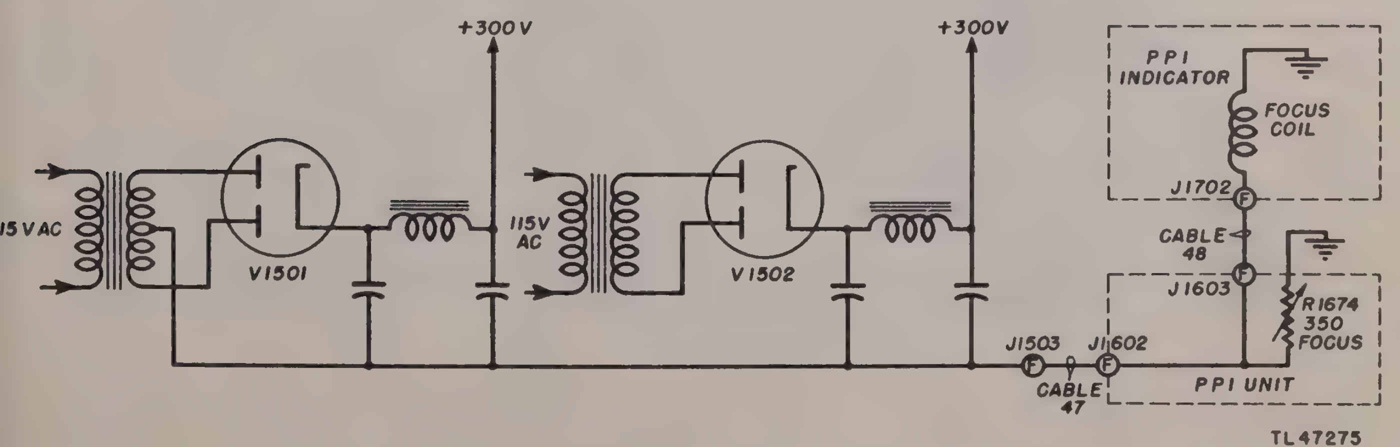

Figure 168. Focus coil circuit.

b. Focusing of the beam in a magnetic PPI scope depends on three conditions: the width of the focus coil, the distance from the center of the focus coil to the center of the screen, and the intensity of the magnetic field. The first two conditions are fixed by the design of the tube, but as every tube differs from another slightly, a means of adjustment must be used to focus the spot correctly. This is accomplished by varying the strength of the magnetic field. Potentiometer R1674 shunted across the focus coil varies the amount of current flow through the coil, changing the intensity. This control, labeled FOCUS, in a screwdriver adjustment on the front of the PPI unit chassis. The strong magnetic field developed by the focus coil is due to the fact that most of the current flow of the regulated and unregulated power supply flows through it (fig. 168).

155. DEFLECTION COILS.

a. The deflection of the beam from the center of the screen is accomplished by the horizontal and vertical deflection coils, wound on the deflection coil yoke L1702. This yoke is placed around the neck of the PPI tube in front of the focus coil. The yoke consists of a stacked square lamination with the coils wound on each of the four legs. The coils wound on the vertical legs of the yoke provide the horizontal sweep, those on the horizontal legs provide the vertical sweep. Each coil is divided into two sections to eliminate distortion and provide a more linear sweep. Thus the entire deflection circuit consists of eight coils producing magnetic fields which are at right angles to each other.

b. As the vertical deflection coils, A and B (fig. 169), are connected between the plates of the vertical output amplifiers, the current flow through the coils is the push-pull output of

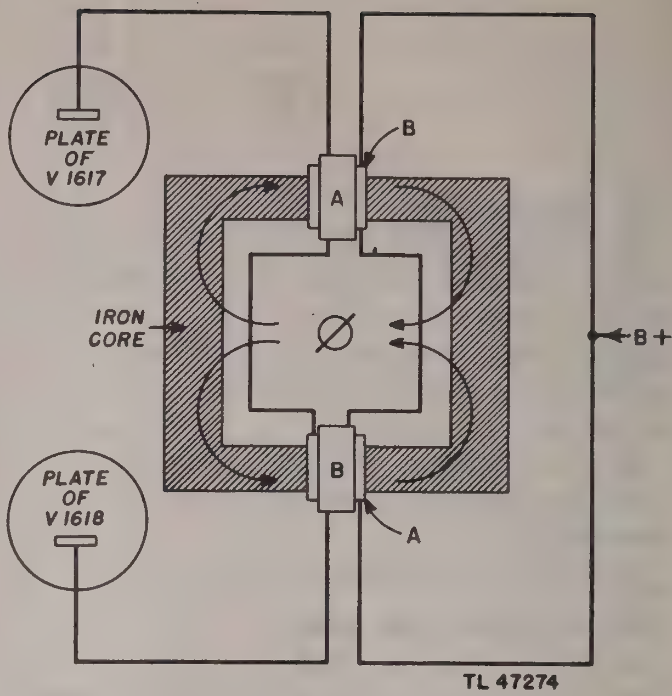

Figure 169. Deflection coils.

the tubes. When the sections carry the same current the net leakage flux is equal and the spot is positioned in the center of the scope. However, when the tubes are unbalanced and one carries more current than the other, one coil has a greater magnetic field than the other, and the spot is moved either up or down proportionately to the difference between the two currents.

c. The horizontal coils are similar to the vertical coils and function in exactly the same manner. The unbalancing of this magnetic field moves the spot sideways in either direction from the center. Since the saw-tooth voltages are applied simultaneously to both the horizontal and vertical coils the position of the spot at any one instant is due to the resultant force of the two voltages at that instant.

SECTION IV

POWER SUPPLY, RECTIFIER RA-69-A

156. GENERAL.

a. Purpose. The PPI power unit supplies all of the operating potentials for the PPI unit and the PPI indicator. A complete schematic diagram is shown in figure 175, and a top view of the unit is shown in figure 170. The PPI power unit contains the following supplies:

(*1*) The positive 4,500-volt high-voltage supply for the anode of the PPI scope using the half-wave rectifier V1503.

(*2*) The positive 270-volt regulated supply using the full-wave rectifier V1502.

(*3*) The positive 300-volt unregulated supply using the full-wave rectifier V1501.

b. Interlock System. An interlock is provided to protect personnel from coming in contact with the high voltage when working on the unit. The interlock system, a simplified diagram of which is shown in figure 171, removes power from the plate transformers of all three rectifiers under any one of the following conditions:

(*1*) If the VR-105-30 (V1507) tube is removed from its socket.

(*2*) If the PPI rear cover of the scope shield is removed.

(*3*) If the cable to the PPI selsyn is disconnected.

(*4*) If the low-voltage power cable to the PPI unit is disconnected.

(*5*) If the low-voltage power cable to the PPI indicator is removed.

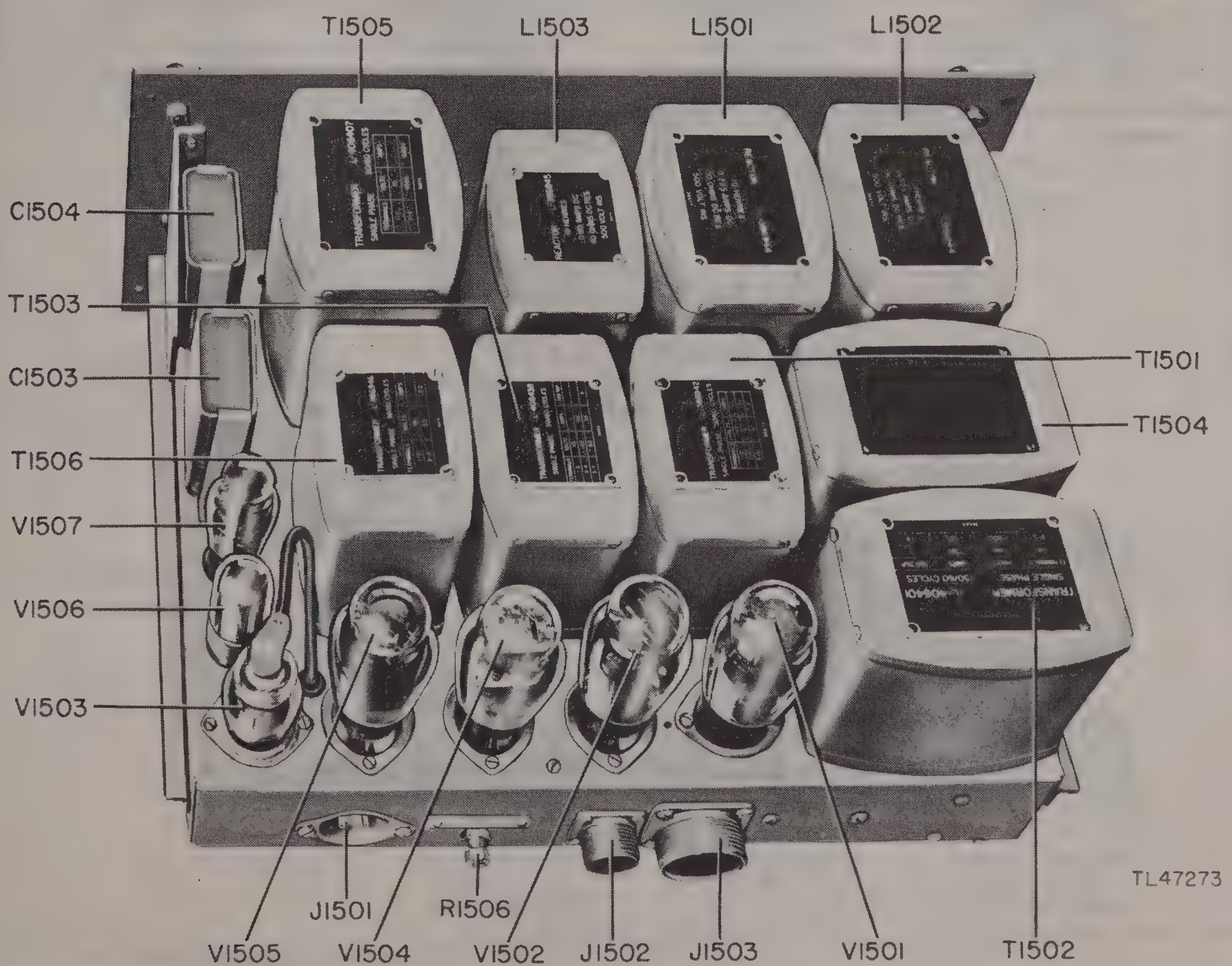

Figure 170. PPI power supply, top view.

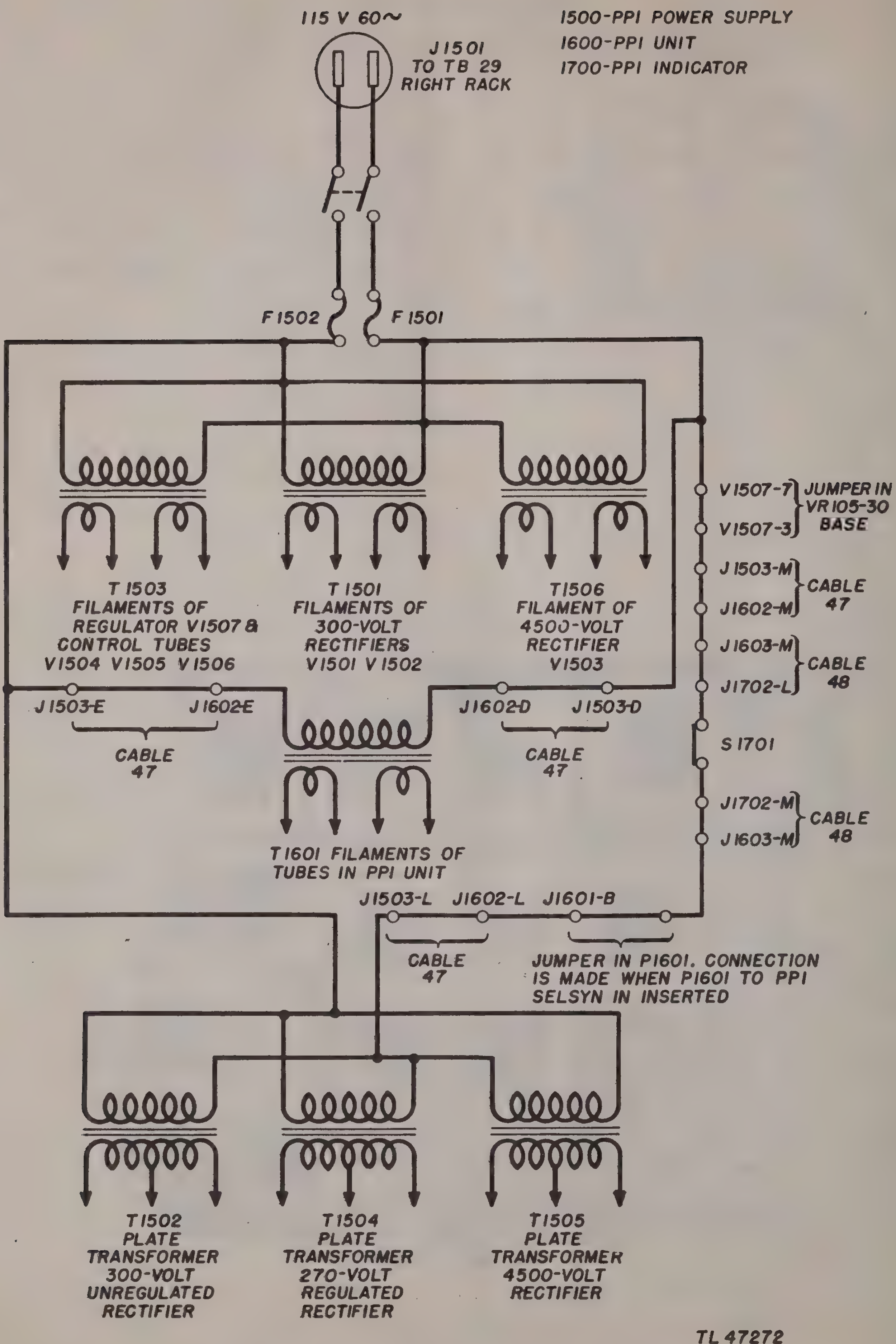

Figure 171. PPI interlock, schematic diagram.

c. High-voltage Supply V1503. The output of this half-wave rectifier V1503 is the + 4,500 volts applied to the graphite coating of the PPI tube through jack J1502. A two-section R-C filter is used, resistor R1512 through R1517 and capacitors C1505 and C1506, with resistors R1529, R1530, and R1531 limiting the maximum current drain and also aiding the filtering action. The bleeder network R1518 to R1528 improves the voltage regulation by limiting the amount of current flow through the circuit and acts as a safety device to discharge the filter capacitors when the power is turned off. A red pilot light on the front panel of the chassis indicates when switch S1501 is ON, and power is applied to the circuit.

d. Unregulated Supply. This 300-volt full-wave power supply, using tube V1501, is the conventional full-wave type. The two-section choke input filter, consisting of inductors L1501 and L1502 and capacitors C1501 and C1502 provides a fairly constant 300-volt output with most of the ripple eliminated. The regulation of the circuit is good even with the large current drain on the rectifier. Resistor R1501 serves as a bleeder to discharge the filter capacitors when the power is removed.

e. Regulated Supply.

(*1*) This 270-volt power supply in conjunction with the regulator circuit has been designed to provide stable operation of the PPI circuits and to eliminate the effects of line voltage variation. The full-wave rectifier is of conventional design, using a capacitor input filter network composed of capacitors C1503 and C1504 and choke L1503. The output voltage developed across the filter capacitor, approximately 400 volts, is used to feed the voltage regulator circuit.

(*2*) The voltage regulator circuit may be compared to an automatic variable resistor in series with the line voltage, which compensates for an increase or decrease of current through the circuit. This circuit is composed of the regulator tubes V1504 and V1505 in series-parallel with the positive side of the output line, a regulator control tube V1506 which controls the bias on the regulator tubes, and a voltage regulator tube V1507 which provides a constant bias of 105 volts on the cathode of the regulator control tube.

(*3*) Referring to the simplified schematic of the circuit in figure 172 assume that the output voltage increases. This could be due to a

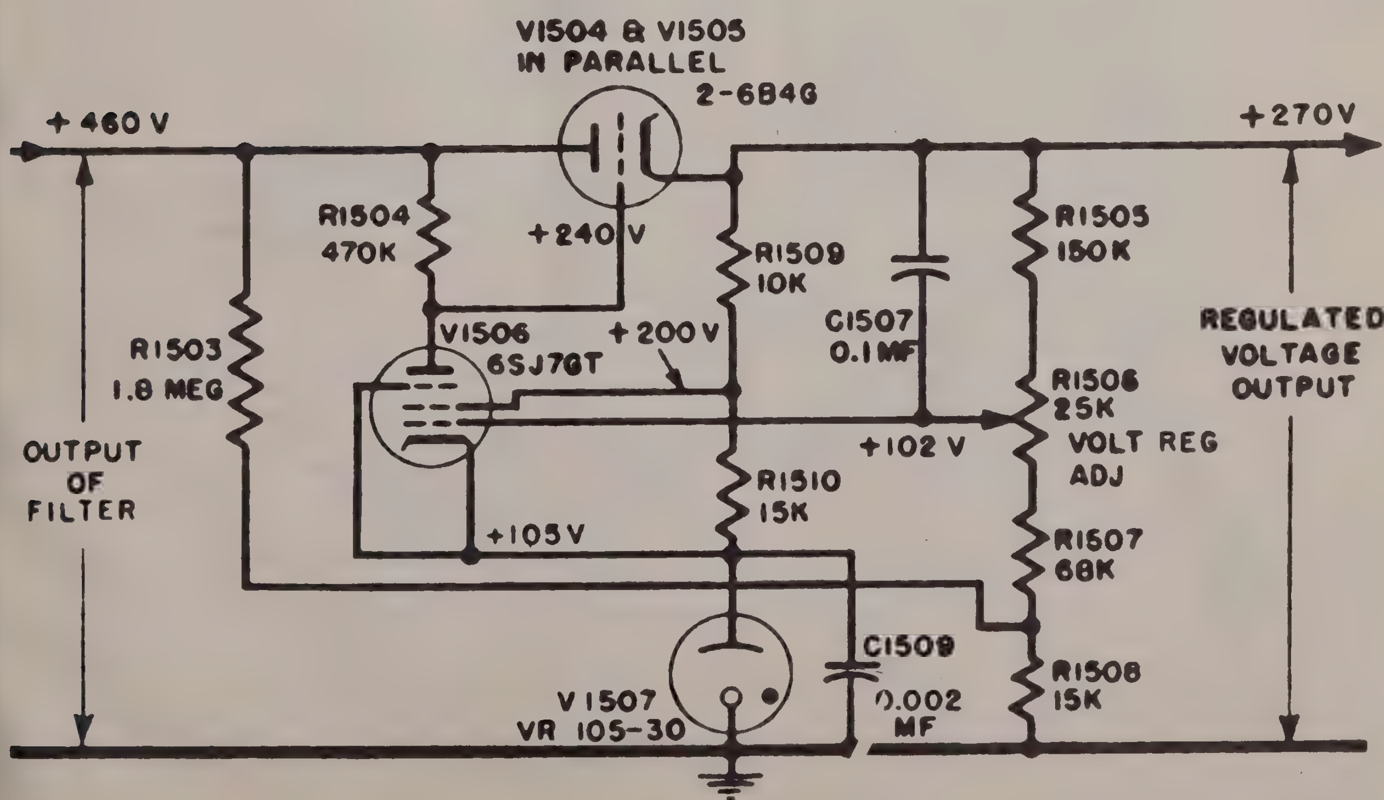

Figure 172. PPI power voltage regulator, simplified schematic diagram.

rise in the line voltage, or an increase in the load resistance which would raise the over-all voltage. The voltage drop across resistors R1505 to R1508 would increase, and a higher voltage would be applied to the grid of the control tube. The tube would conduct more, the plate voltage would decrease and this drop coupled to the grids of the regulator tubes would increase the resistance of the tubes and drop the output voltage automatically. If the output voltage decreases, the reverse action takes place and the resistance of the regulator tubes decreases and raises the voltage to the normal value. Because of the high amplification of V1506 the output voltage is held constant over a wide range of load or input changes, and reacts rapidly to compensate for these changes.

(*4*) The gas regulator tube is used to provide the constant bias for the control tube as it is essential that the cathode of V1506 operates at exactly the same potential, with only the voltage variations at the grid causing the tube to increase or decrease conduction.

(*5*) The VOLT REG ADJ Potentiometer R1506 normally keeps the potential of the grid of V1506 at about +102 volts, although in respect to the 105 volts on the cathode it is effectively at –3 volts. This allows the tube to operate with class A bias permitting a linear voltage swing. The regulator circuit is designed to provide efficient regulation at +270 volts, but in order to compensate for any variation in the circuit values potentiometer R1506 is made variable. The setting of this control, which determines the operating point of the regulator circuit is adjusted usually until the output is 270 volts under load. When first adjusting the output voltage to the desired level, R1506 should be moved slowly because the high amplification of V1506 produces a large output change for a small input change.

(*6*) Resistor R1503 compensates for changes in the line voltage. An increase of the output filter voltage raises the bias on the control tube and in turn the action of the regulator offsets the voltage rise. Capacitor C1507 between the output and the grid of V1506 compensates for rapid changes in the output voltage, as the full voltage change is applied to the grid instead of a tapped-off portion when the fluctuations occur.

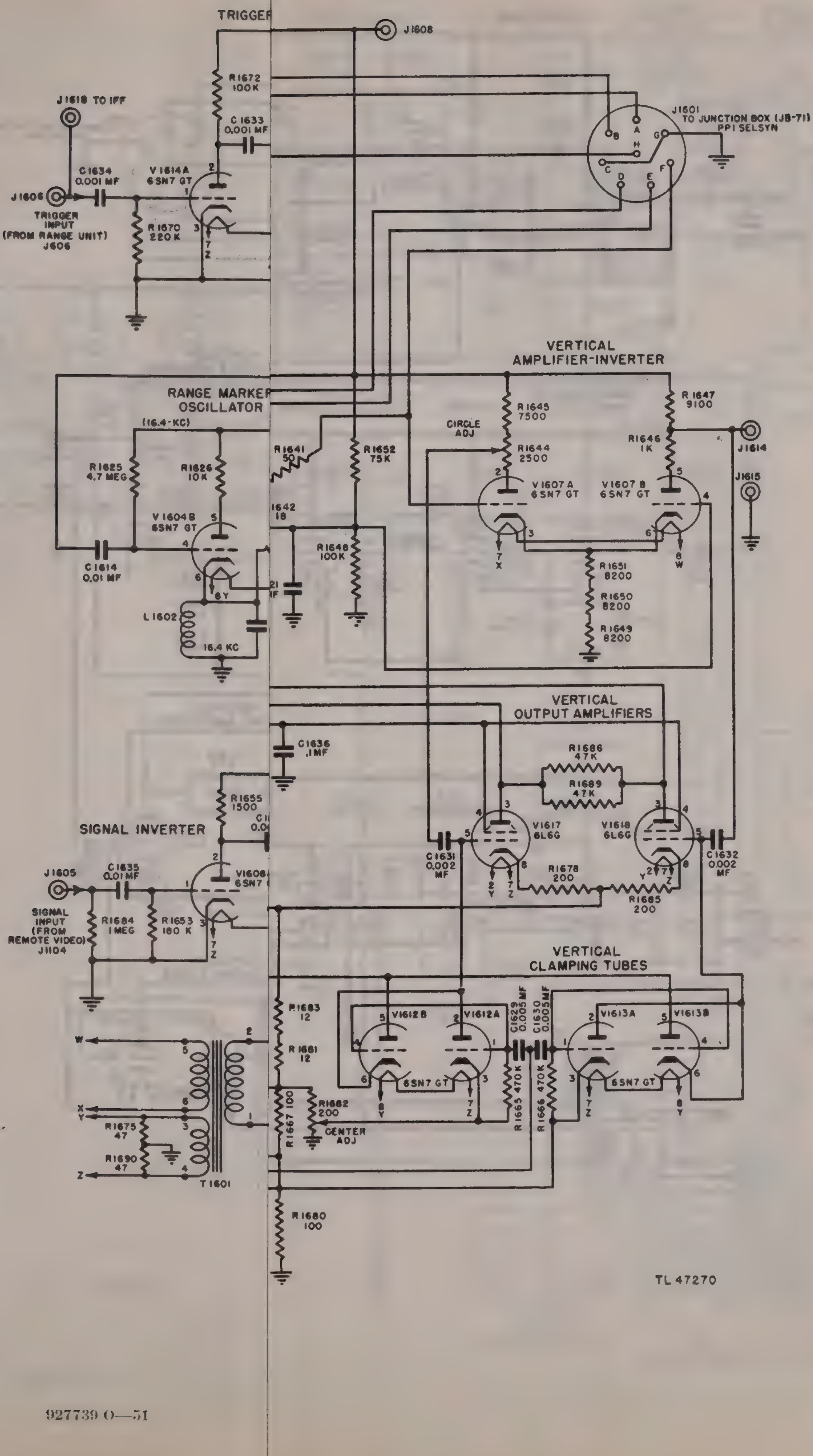

Figure 173. PPI unit, complete schematic diagram.

rise in the line voltage, or an increase in the load resistance which would raise the over-all voltage. The voltage drop across resistors R1505 to R1508 would increase, and a higher voltage would be applied to the grid of the control tube. The tube would conduct more, the plate voltage would decrease and this drop coupled to the grids of the regulator tubes would increase the resistance of the tubes and drop the output voltage automatically. If the output voltage decreases, the reverse action takes place and the resistance of the regulator tubes decreases and raises the voltage to the normal value. Because of the high amplification of V1506 the output voltage is held constant over a wide range of load or input changes, and reacts rapidly to compensate for these changes.

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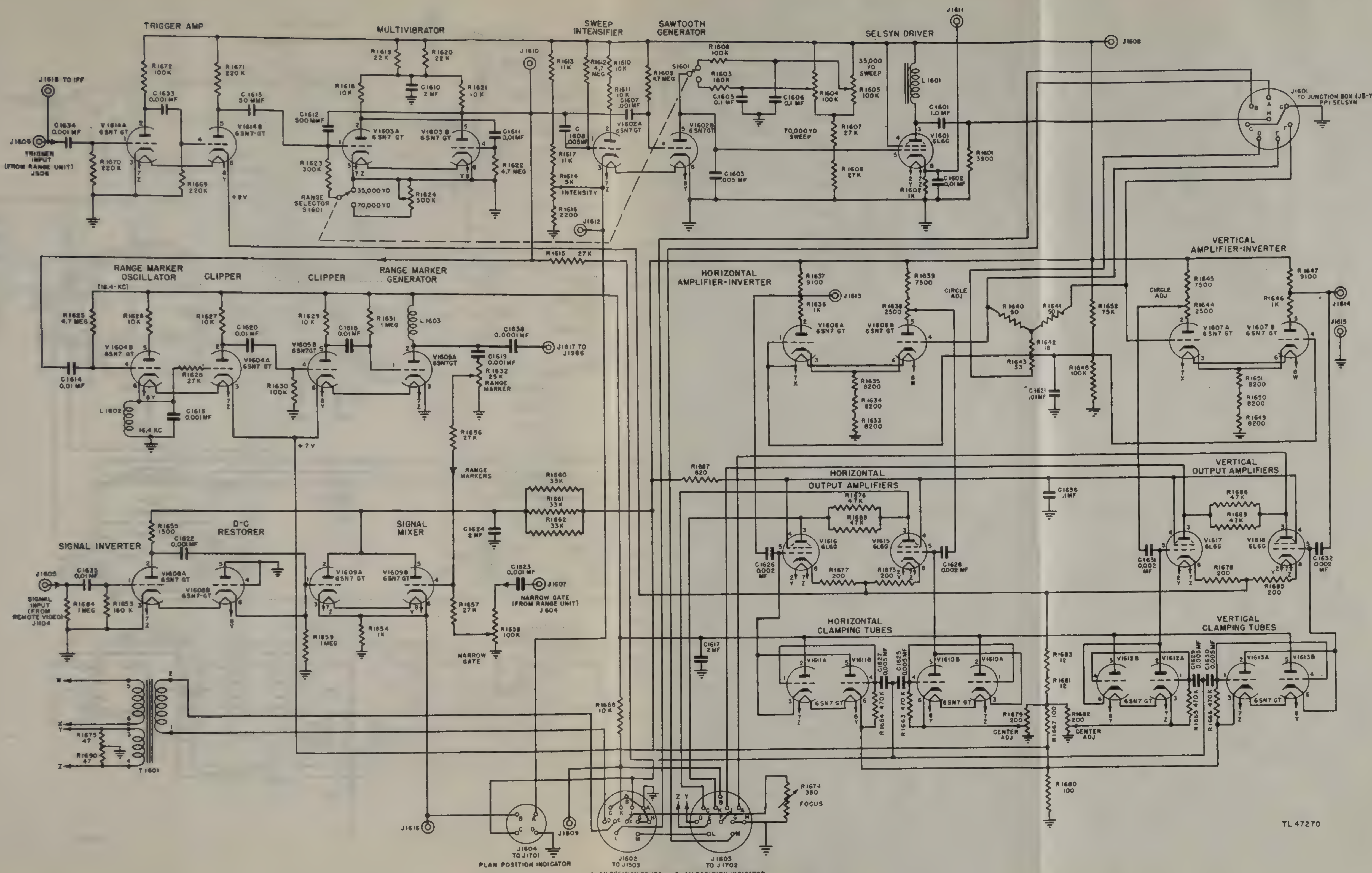

Figure 173. PPI unit, complete schematic diagram.

Figure 173. PPI unit, complete schematic diagram.

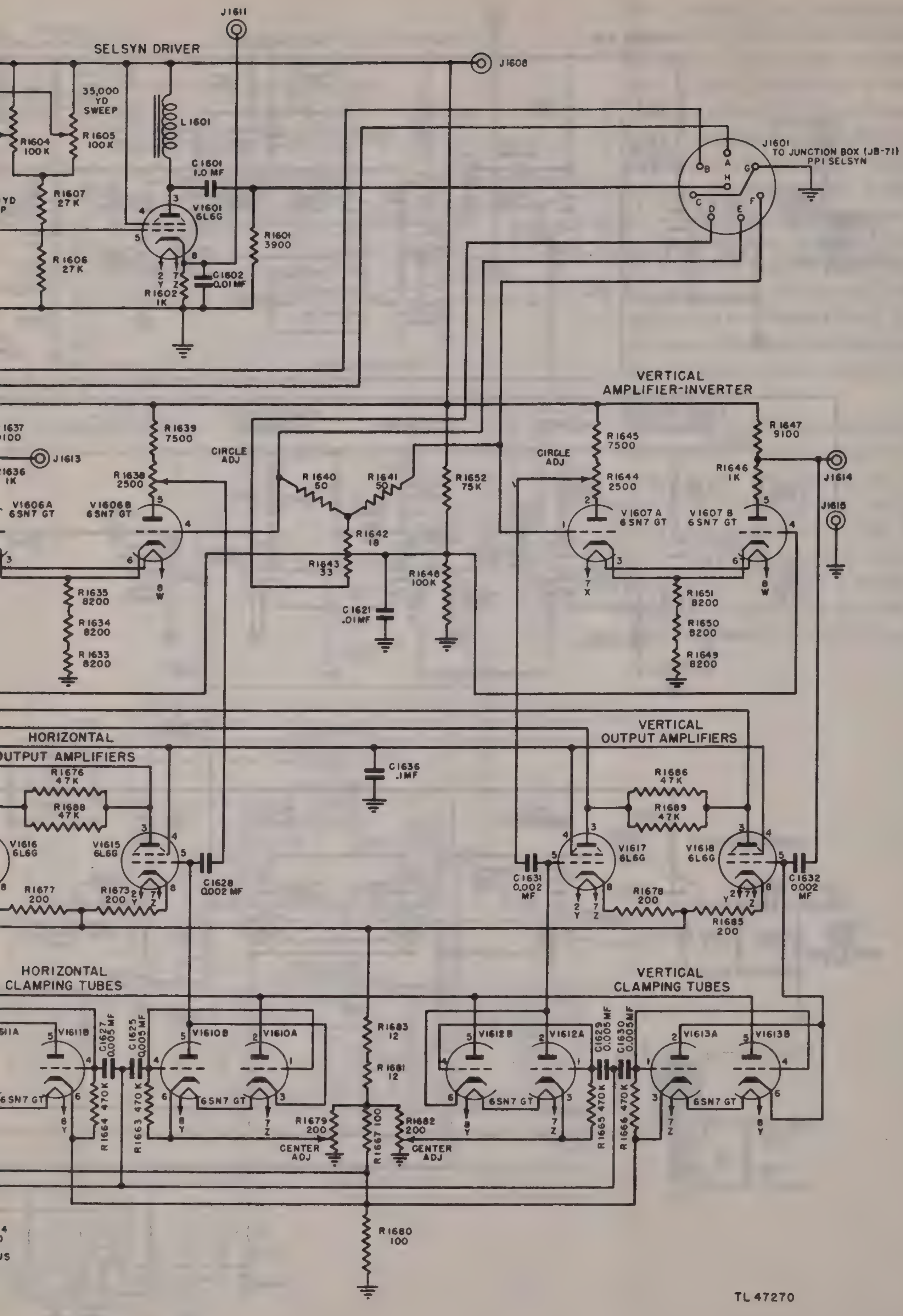

Figure 173. PPI unit, complete schematic diagram.

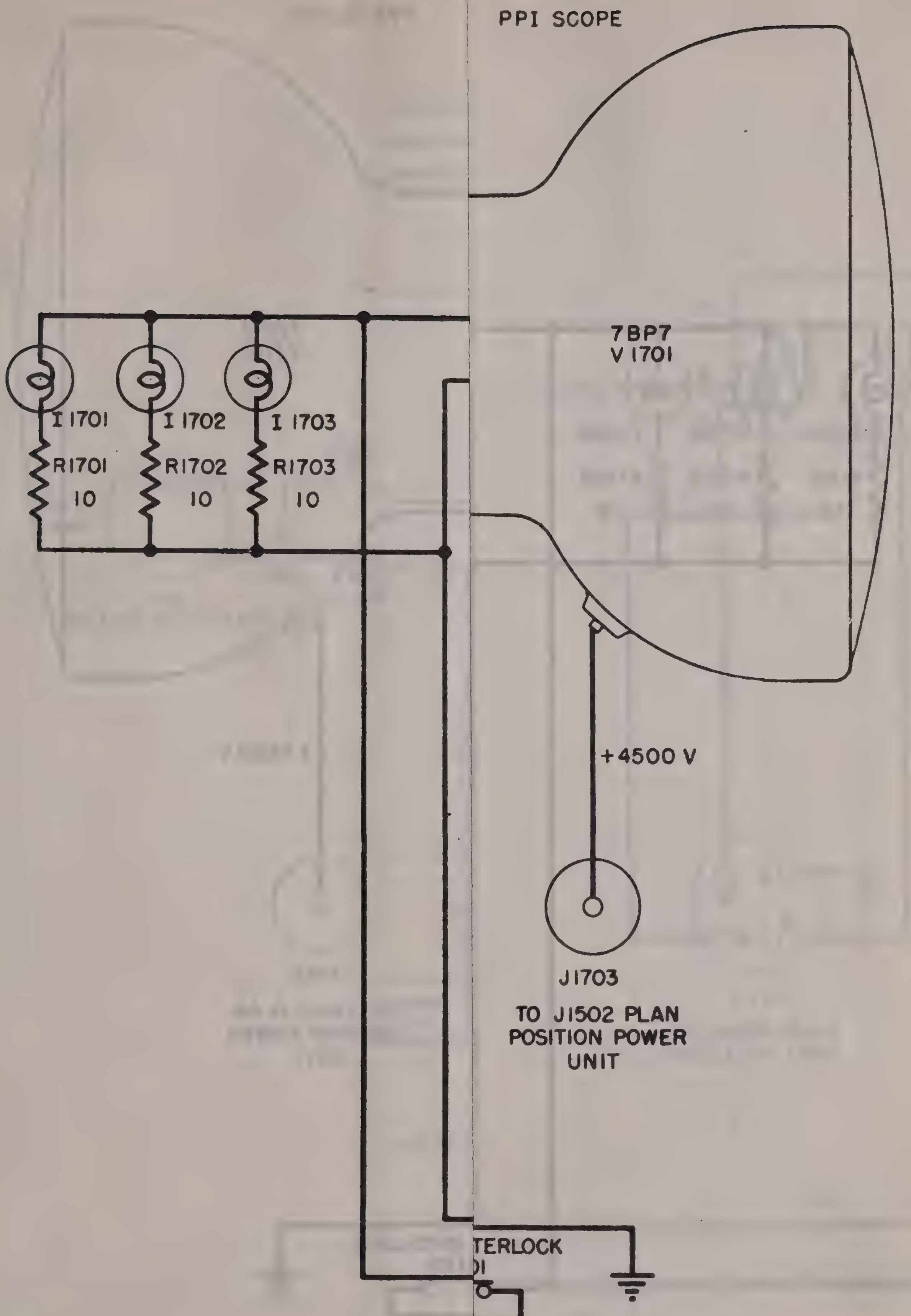

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Figure 174. PPI indicator, complete schematic diagram.

Figure 173. PPI unit, complete schematic diagram.

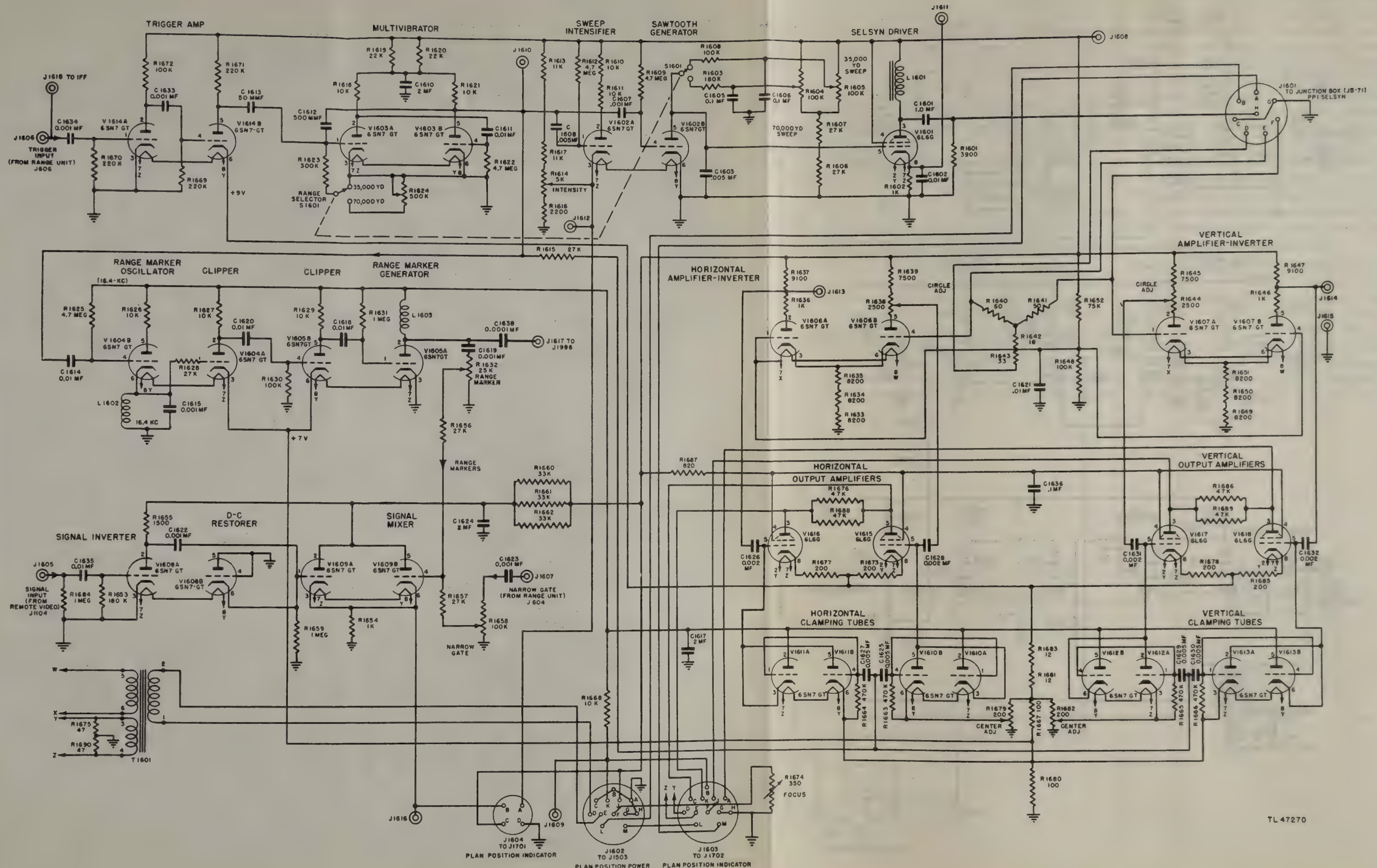

Figure 173. PPI unit, complete schematic diagram.

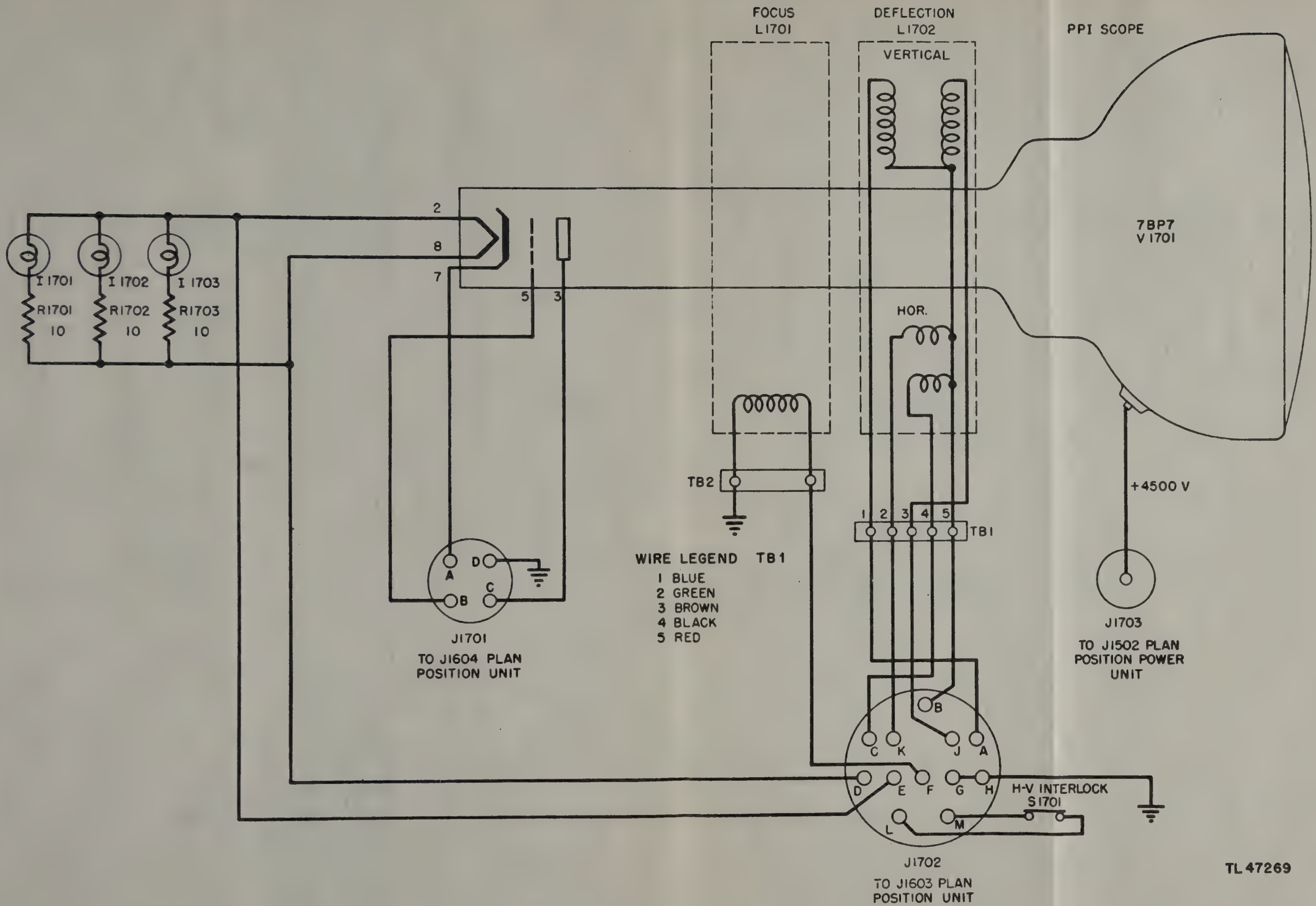

Figure 174. PPI indicator, complete schematic diagram.

Figure 174. PPI indicator, complete schematic diagram.

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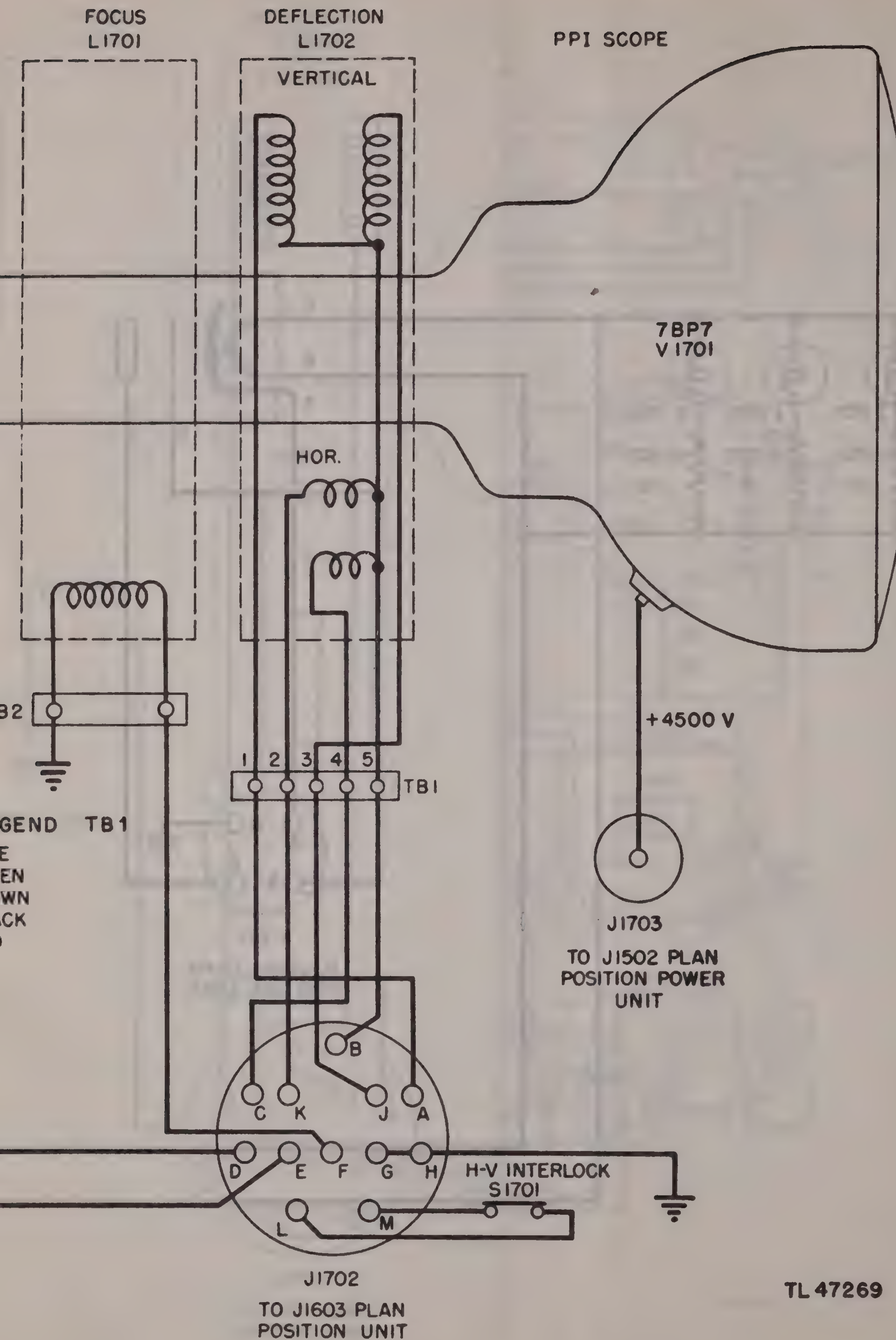

Figure 174. PPI indicator, complete schematic diagram.

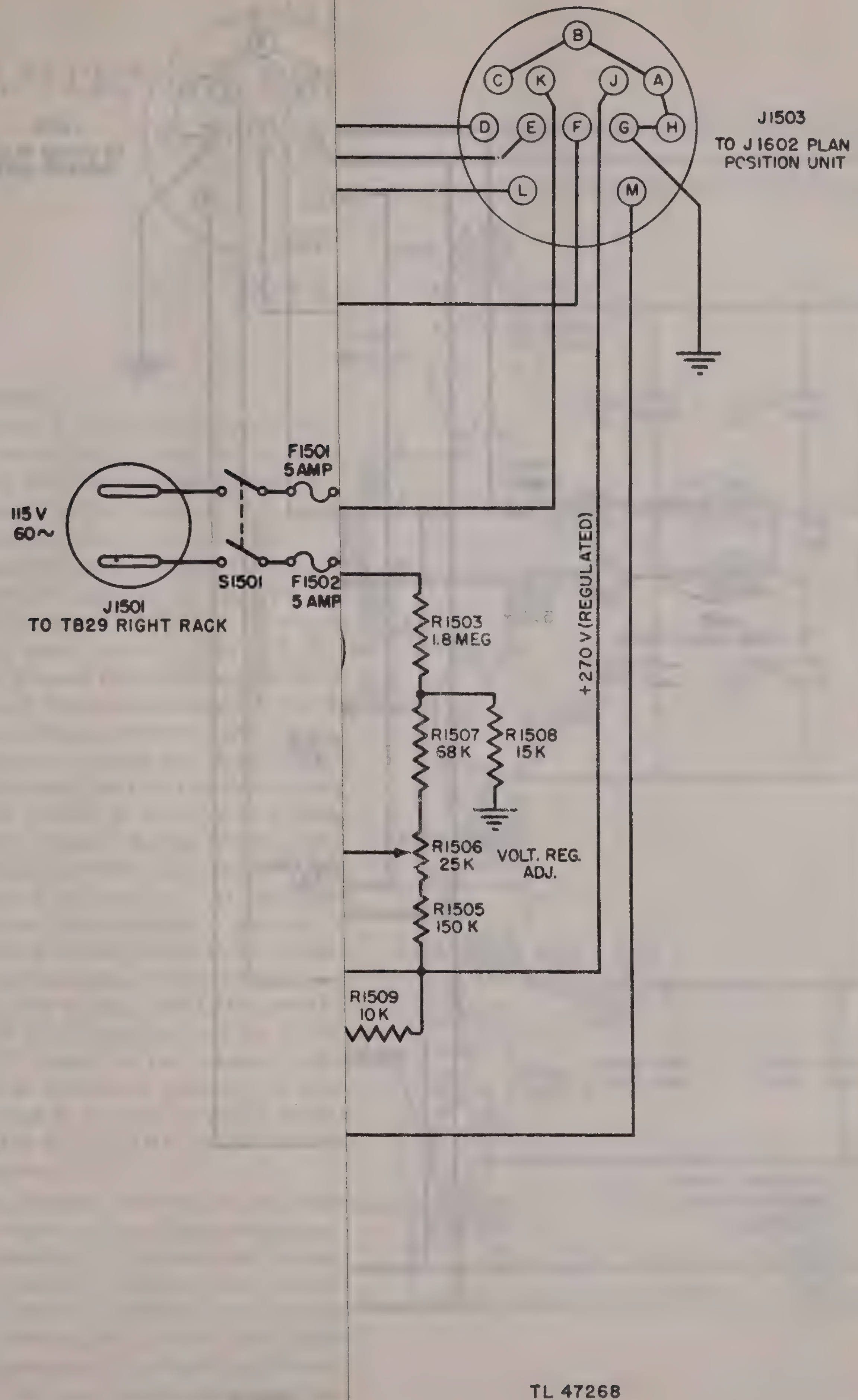

Figure 175. PPI power supply, complete schematic diagram.

Figure 174. PPI indicator, complete schematic diagram.

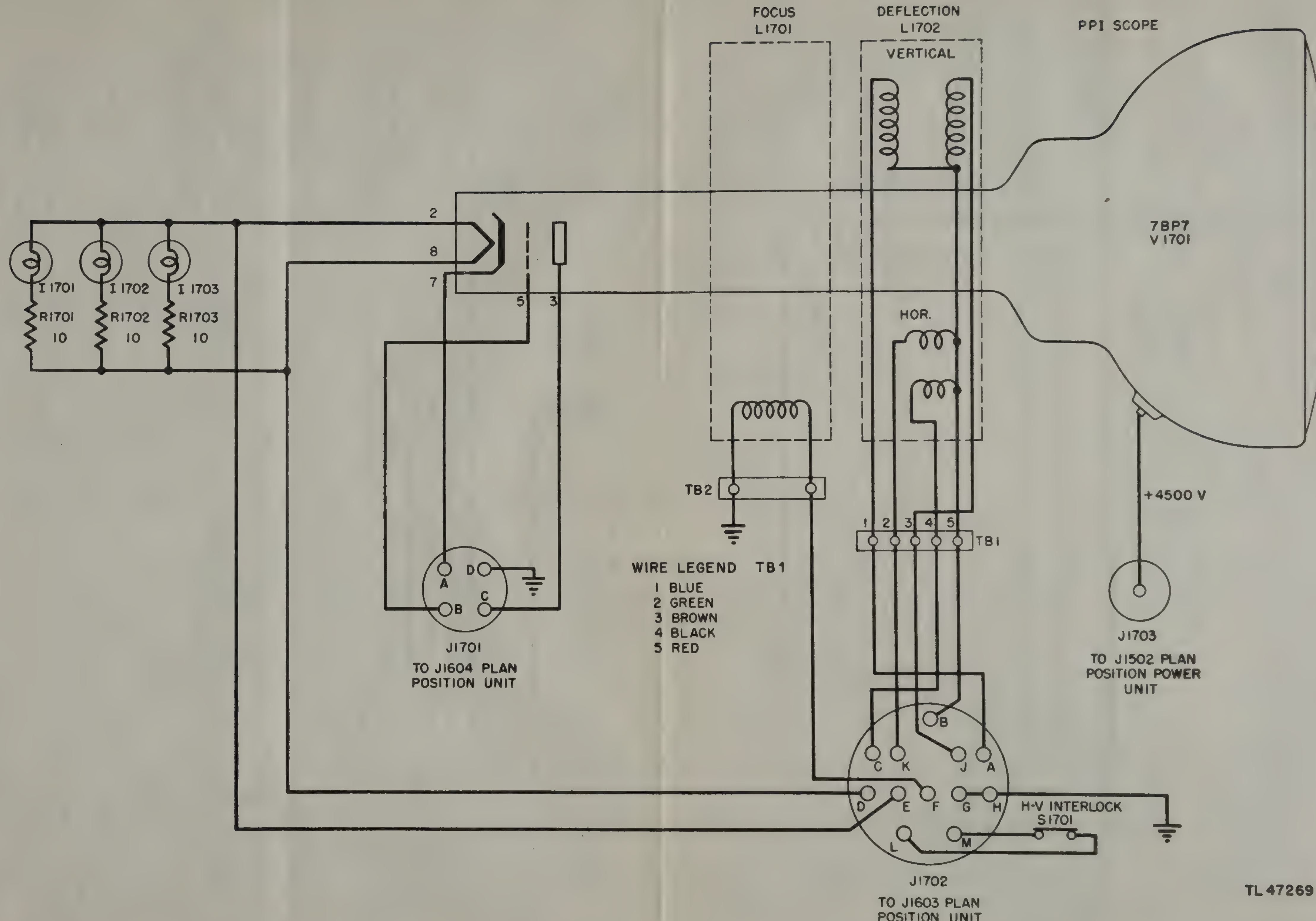

Figure 174. PPI indicator, complete schematic diagram.

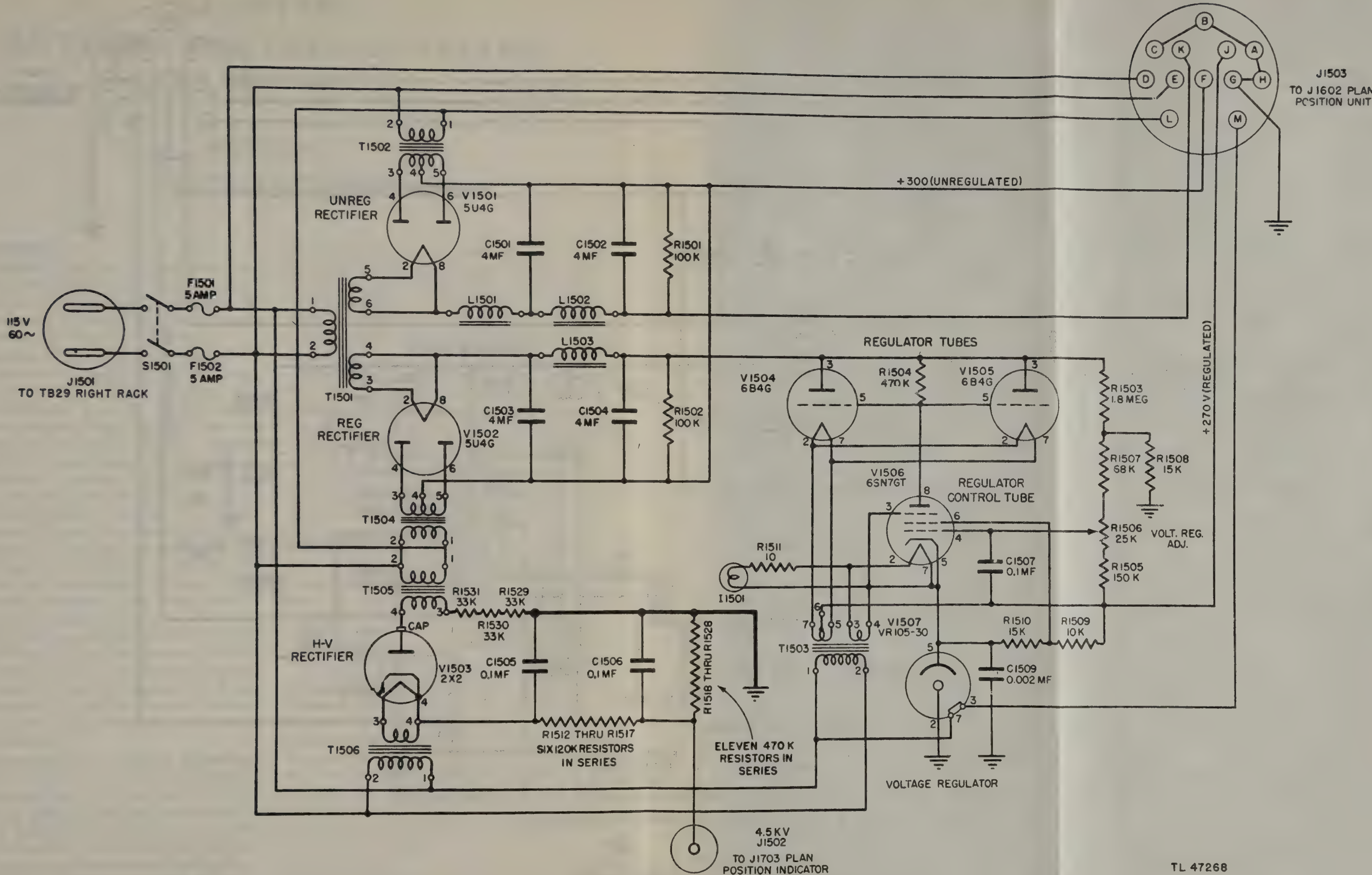

Figure 175. PPI power supply, complete schematic diagram.

Figure 175. PPI power supply, complete schematic diagram.

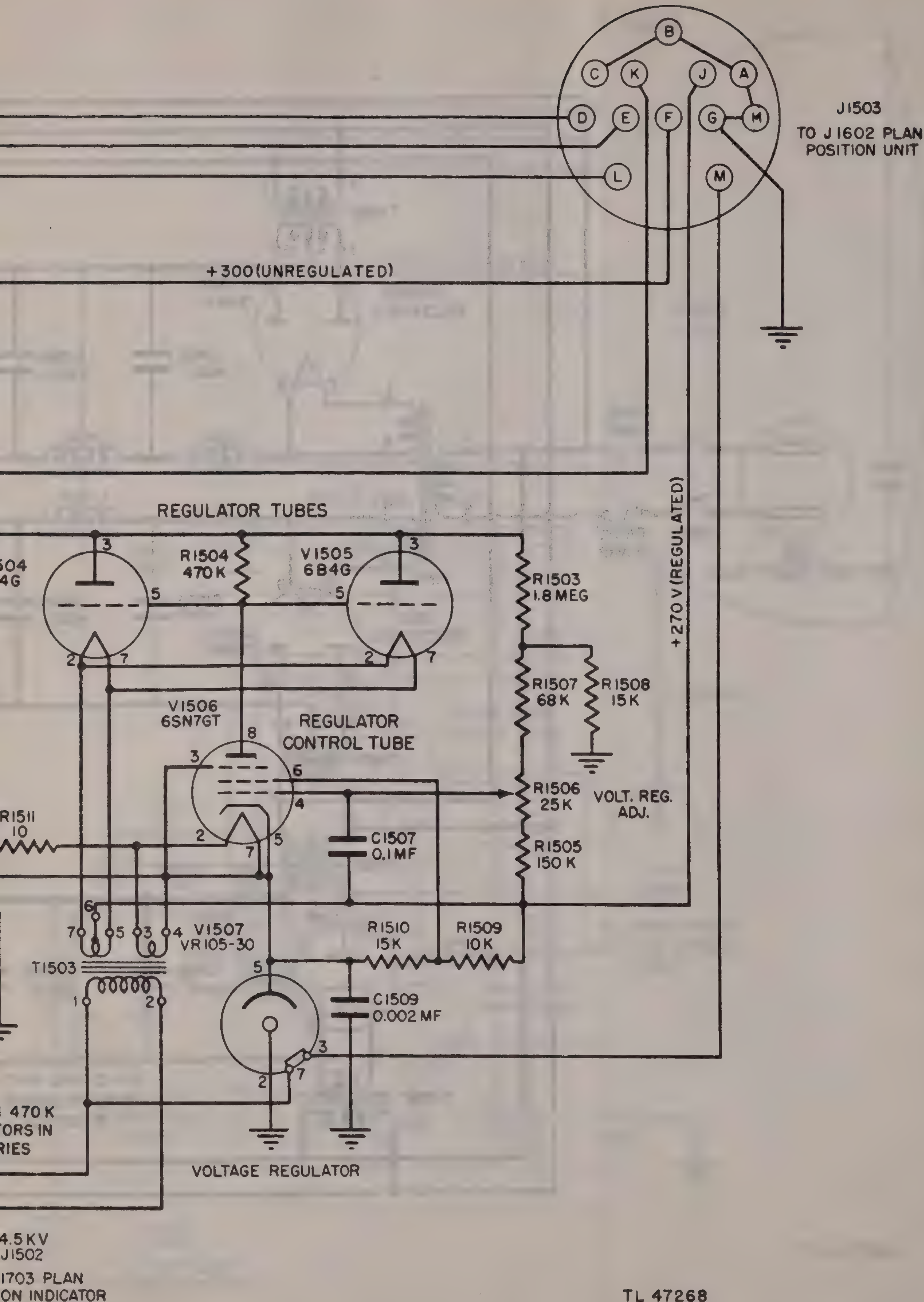

Figure 175. PPI power supply, complete schematic diagram.

CHAPTER 7
ANTENNA POSITIONING SYSTEM

SECTION I
INTRODUCTION

157. FUNCTION.

The function of the antenna positioning system is to position the antenna in azimuth and elevation so that the antenna points in the direction desired by the operator. Four methods of positioning the antenna are provided.

a. PPI Scan. PPI scan is used to search for targets which are detected on the PPI scope. When the CONTROL SWITCH on the indicator-control panel is set to the PPI SCAN position the antenna rotates through 6,400 mils in azimuth and 356 mils in elevation. Any 356-mil sector in elevation between 0 and 1,600 mils can be chosen by turning the elevation handwheel to the lower limit of the desired sector. The antenna rotates in azimuth at a rate of approximately 6 rpm. As the antenna rotates 5½ revolutions in azimuth, it is elevated through a 356-mil sector in elevation. As the antenna rotates the next ½-revolution in azimuth, it is automatically depressed to its initial elevation position. This scanning cycle is repeated automatically as long as the CONTROL SWITCH is in the PPI SCAN position, and the ELEVATION SCAN clutch on the antenna position control unit is in the ON position. It is also possible to scan in one fixed angle of elevation by turning the ELEVATION SCAN clutch to the OFF position.

b. Manual. Manual tracking of the antenna is used to follow a target before switching to automatic tracking. It is also used to search any desired sector in azimuth and elevation. When the CONTROL SWITCH is set to the MANUAL position, the antenna can be positioned by the operator in azimuth and elevation by means of the two handwheels on the panel of the antenna position control unit.

c. Automatic. When the CONTROL SWITCH is set to the AUTOMATIC position, the antenna automatically follows the target in azimuth and elevation, provided that the target is kept within the narrow gate on the 2,000-yard range scope. The target must be within a range of 32,000 yards before it can be tracked automatically. The two signals which position the antenna on the target are the error voltage (produced in the automatic tracking unit) and the reference voltage (produced by the reference generator on the pedestal).

d. Remote. When the CONTROL SWITCH is set to the REMOTE position, the antenna is positioned in azimuth and elevation from the gun director. When operating with the M9 or M10 director and the target has been located in the telescopes of the director, the radar set operator turns the CONTROL SWITCH to the REMOTE position and the gun director takes over the antenna positioning operation. The choice of remote operation depends entirely upon the tactical use the battery commander wishes to make of the radar set and gun director.

158. DEFINITIONS.

a. Pointing Error. In describing the operation of the antenna positioning system, the term "pointing error" is used to express the difference between the actual direction in which the antenna is pointing and the direction desired to bring the antenna on target. The polarity of the azimuth and elevation components of the pointing error is important because this polarity specifies whether the antenna must be rotated clockwise or counterclockwise in azimuth and whether the antenna must be depressed or elevated.

b. Error Signal and Reference Voltage. All four methods of antenna positioning require that an "error signal" and a "reference voltage" be fed into the system.

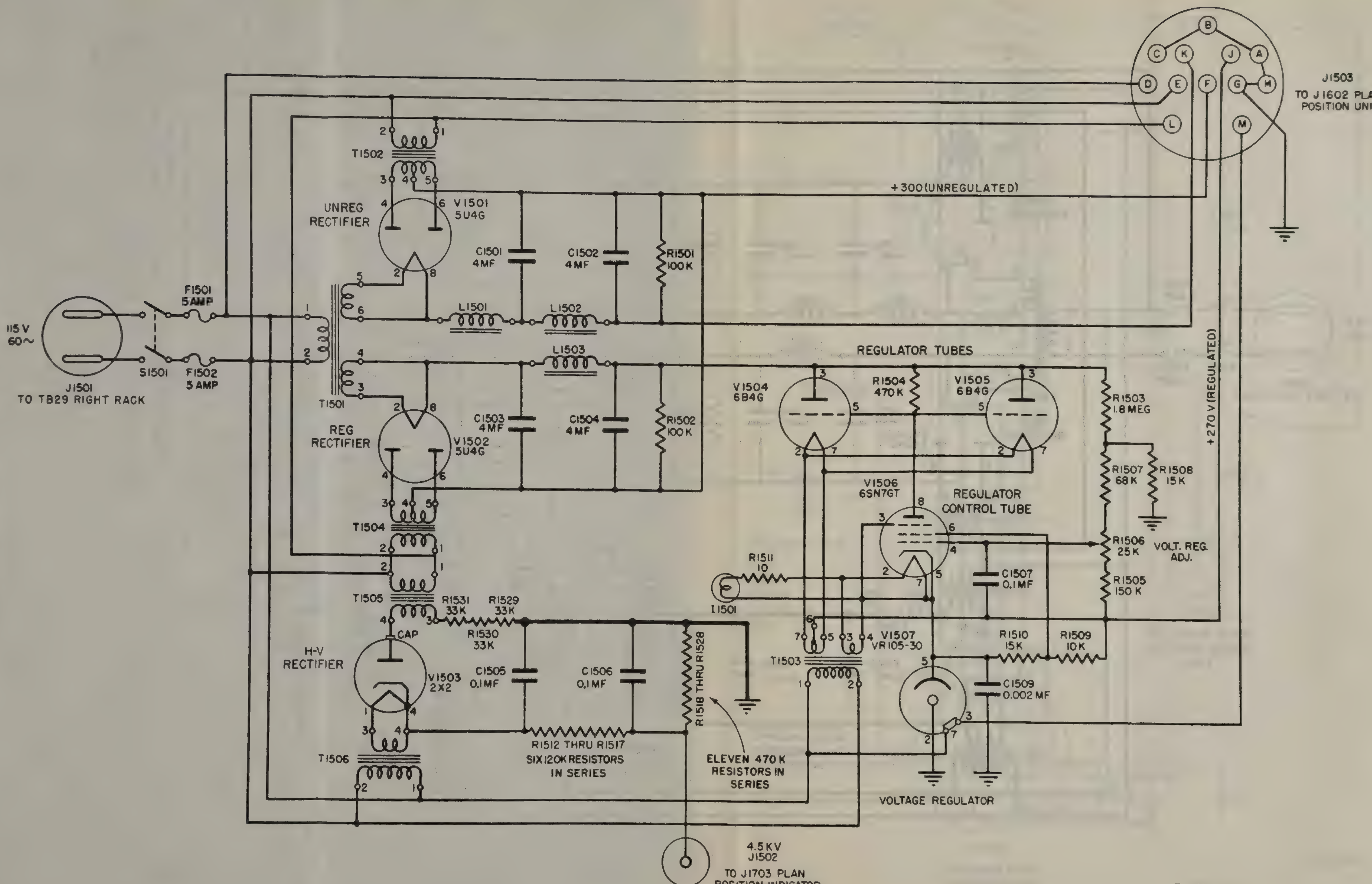

Figure 175. PPI power supply, complete schematic diagram.

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b. Error Signal and Reference Voltage. All four methods of antenna positioning require that an "error signal" and a "reference voltage" be fed into the system.

(*1*) The error signal is a voltage which provides information concerning the direction and magnitude of the pointing error. In automatic operation this error signal is a measure of the amount by which the antenna is off target; and in manual, PPI scan, and remote operation, the error signal is a measure of the amount the actual position of the antenna differs from the position desired by the operator. In all four methods of operation, the error voltage is separated into its azimuth and elevation components to position the antenna in both azimuth and elevation.

(*2*) The reference voltage is the means by which the polarity of the error signal is determined. The azimuth and elevation reference voltages are always 90 degrees out-of-phase with each other. In automatic operation, the reference voltage is the means by which the error signal is separated into its azimuth and elevation control signal components, and these reference voltages are supplied by the two-phase reference generator which is mounted on the antenna shaft and is driven by the spinner motor. In manual positioning the azimuth and elevation reference voltages are supplied by the 60-cycle a-c supply to the set. In all methods of operation, the azimuth reference voltage is in phase with the error signal which is produced by a pure azimuth pointing error, and the elevation reference voltage is in phase with the error signal which is produced by a pure elevation pointing error.

159. SIMPLIFIED BLOCK DIAGRAM (fig. 176).

A simplified block diagram of the antenna positioning system for the azimuth channel only is shown in figure 176. The elevation channel is identical to the azimuth channel.

a. Automatic Operation. With the CONTROL SWITCH in the AUTOMATIC position, the signals from the automatic tracking unit and from the reference generator are fed to the azimuth control channel in the azimuth and elevation tracking unit. The video input to the automatic tracking unit contains the 30-cycle error voltage resulting from conical scanning (subpar. 160**a** (*1*)). This error voltage is

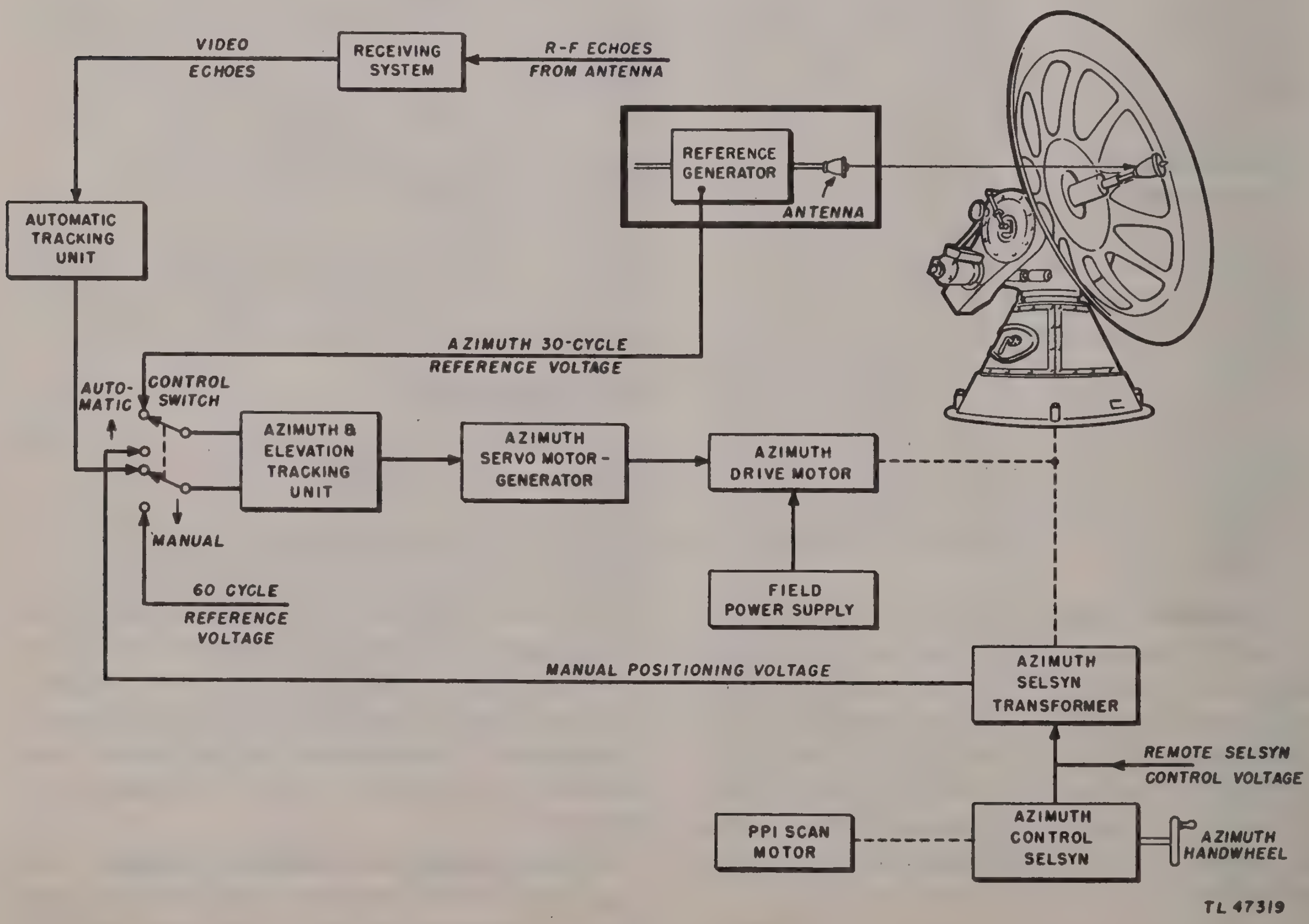

Figure 176. Antenna positioning system, simplified block diagram.

detected and fed through the control switch to the azimuth and elevation tracking unit. The control voltage output from the azimuth and elevation tracking unit is a push-pull d-c voltage which is fed to the azimuth servo motor-generator. The motor generator output is used to control the direction of the azimuth drive motor and thus the direction of movement of the antenna. The drive motor and antenna move until the error voltage is eliminated, then the drive motor stops and the antenna will not move. The field rectifier supplies constant d-c power for the drive motor.

b. Manual Positioning. Manual positioning includes manual, PPI scan, and remote operation. In these three types of operation the controlling element is the control selsyn (either azimuth or elevation) in the antenna position control unit or gun director. With the CONTROL SWITCH in the MANUAL or PPI SCAN position, any movement of the azimuth control selsyn either by the azimuth handwheel or the PPI scan motor causes a voltage to be induced in the azimuth selsyn transformer. Any movement of the gun director telescope also causes a voltage to be induced when the CONTROL SWITCH is in the REMOTE position. The magnitude of the induced voltage depends on the relative positions of the selsyn transformer and control selsyn. This induced voltage should be zero when the two selsyns are in line, and maximum when there is 180 degrees difference in the positions of the selsyns. The output of the selsyn transformer is the manual positioning error voltage which is combined with a 60-cycle reference voltage in the commutator and squarer stages of the azimuth and elevation tracking unit. From this point on, the circuit is exactly the same as for automatic operation. The output of the azimuth and elevation tracking unit, the azimuth servo motor-generator, and the azimuth drive motor is used to position the antenna so that the error-voltage output of the selsyn transformer is reduced to zero.

160. COMPLETE BLOCK DIAGRAM (fig. 178).

a. Automatic Operation. A complete block diagram of the entire antenna positioning system is shown in figure 178 and a block diagram of the circuits and components used in automatic tracking is shown in figure 182. With the CONTROL SWITCH in the AUTOMATIC position, the manual-automatic relay contacts shown in figure 178 are in the up position. Before considering the circuits shown in the block diagram consider first how the error signals for automatic tracking are produced, and then how these error signals are combined with the azimuth and elevation reference voltages to produce the azimuth and elevation control voltages for automatic tracking.

(*1*) *Production of Error Signal.* The nature of the beam radiated by the antenna is the basis of automatic tracking. Figure 177 shows the beam of energy sent out by the antenna, and the relative strength of echoes from targets in various positions in relation to the beam. If the echo energy from a target at the center of the beam is taken as 100 percent (maximum) then the energy from a target ½ degree off the center of the beam is 95 percent, and the energy from a target 1½ degrees off the center of the beam is 80 percent. Beyond 1½ degrees the decrease in echo energy is very rapid, the value being about 40 percent at 2 degrees, and nearly zero at 5 degrees.

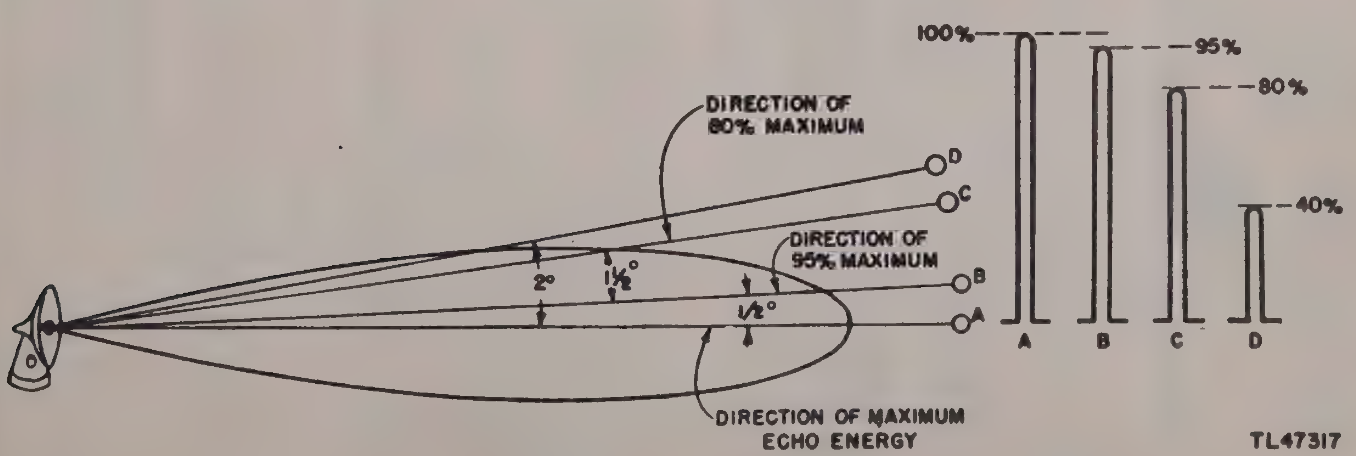

Figure 177. Antenna beam.

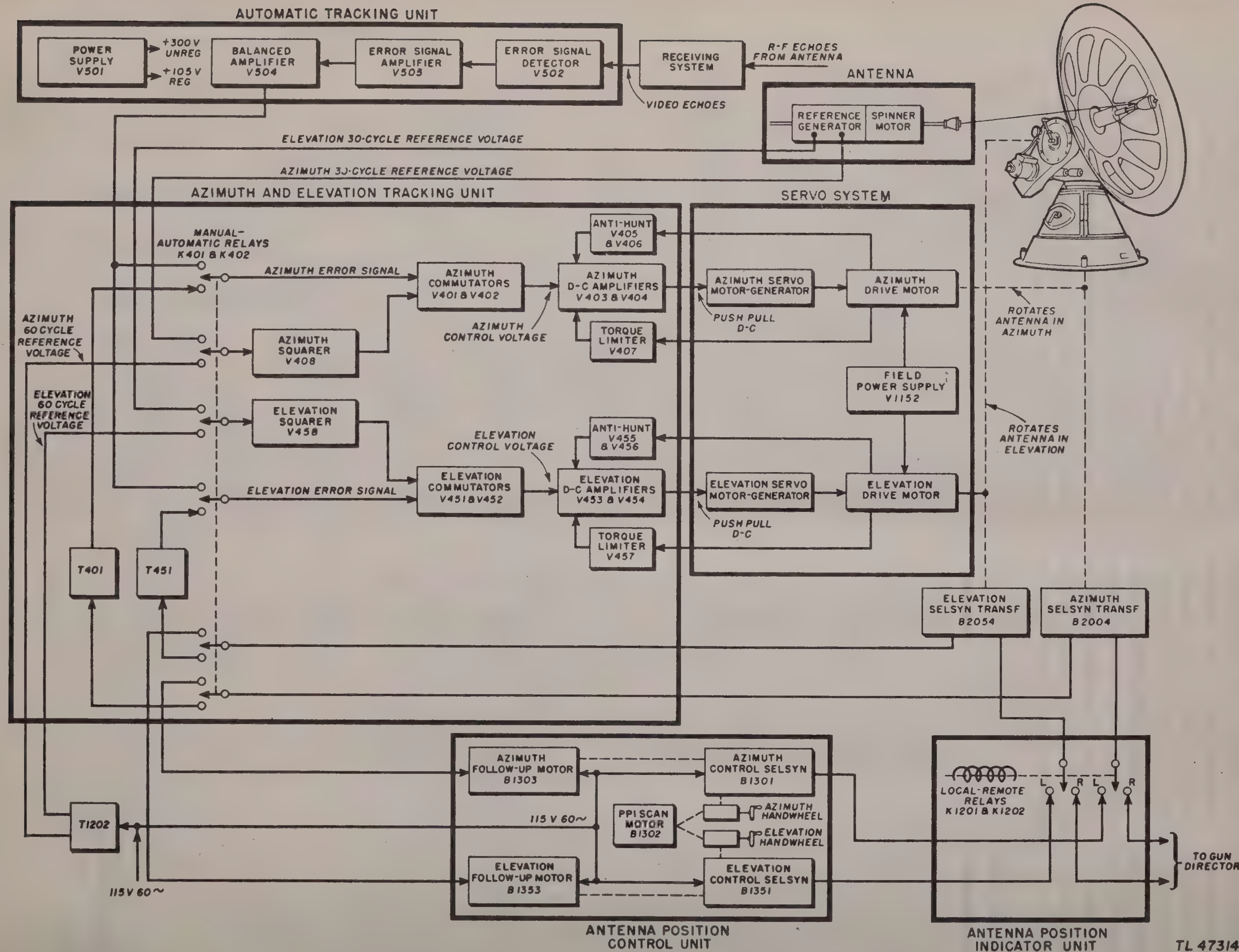

Figure 178. Antenna positioning system, complete block diagram.

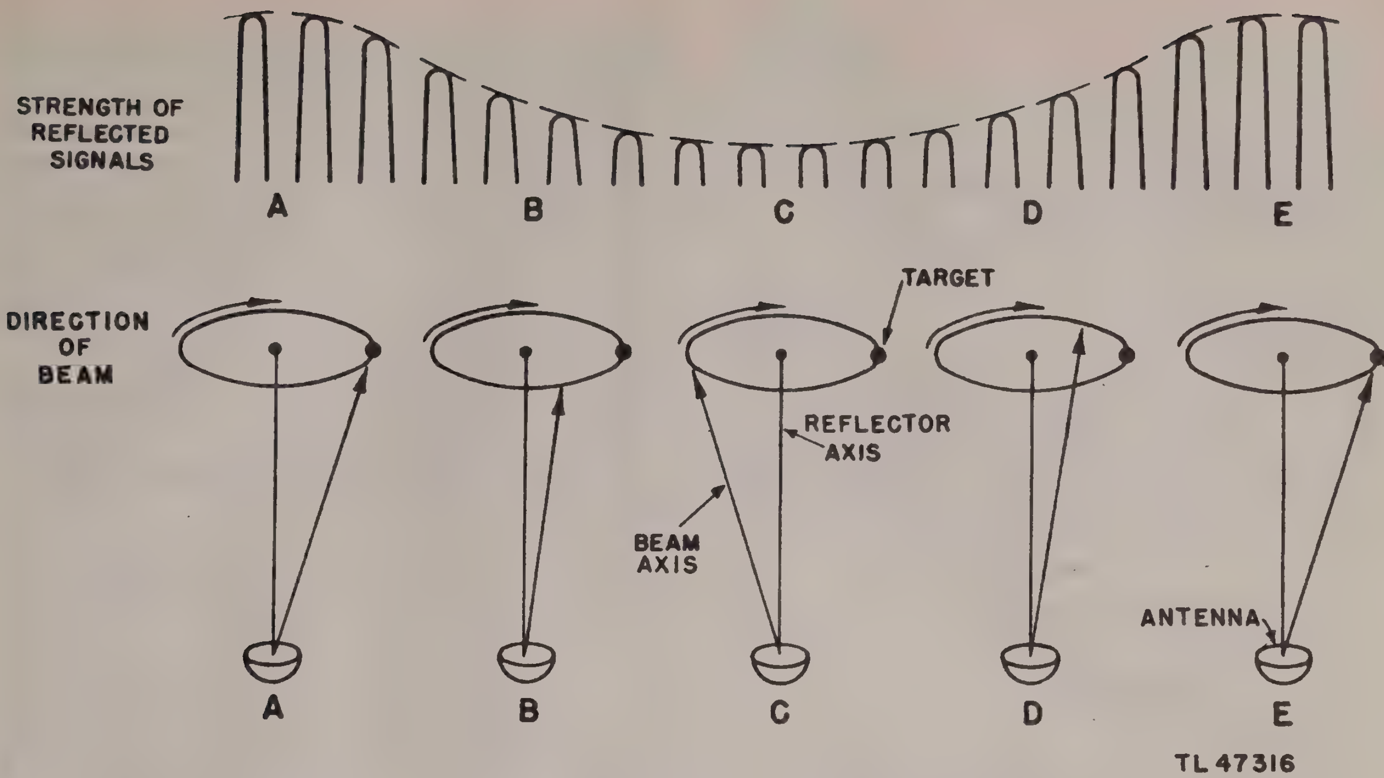

Figure 179. Production of 30-cycle variation in error signals.

(*a*) *Rotation of the Beam.*

1. To produce the error signal required for automatic tracking, it is necessary to explore or scan the space in the vicinity of the target. In automatic operation, the space in the vicinity of the target is explored by producing a beam slightly to one side of the axis of the reflector, and by rotating this off-center beam around the reflector axis. When this is done, the energy goes out into space in the form of a cone (fig. 51) rather than in a straight line, and so this method of scanning is called conical scanning. The axis of the cone is the axis of the reflector, so that the cone as a whole points in the same direction as the reflector; but the beam itself points at an angle of 1½ degrees off the axis of the reflector and revolves around the reflector axis. In figure 51 it is noted that a target on the reflector axis always receives 80 percent of the maximum energy of the beam, while a target 1½ degrees off the reflector axis receives energy which varies from 100 percent to less than 30 percent of maximum.

2. As described in chapter 3, the pedestal contains a spinner motor which rotates the antenna at the rate of 30 rps, and thus rotates the beam around the reflector axis at the rate of 30 rps. The direction of the beam after half a revolution of the antenna will have changed from the upper position to the lower position as shown in figure 180. Comparing the return signals in figure 180 (A) for a target 1½ degrees off the reflector axis shows that the position of both the target and the reflector axis are the same in both cases, yet one return signal is much stronger than the other because of the rotation of the beam. Figure 180 (B) shows the return signals from a target on the reflector axis, and comparing these return signals shows that the position of the target and the reflector axis are the same and the return signals are of equal strength. Figures 180 (A) and 180 (B) show only the extreme positions of the beam, but as the beam rotates between these extreme positions the echo signals vary gradually in strength as shown in figure 179. Figure 179 shows only 16 echo signals per revolution of the antenna, but actually there are almost 60, which makes the variation per echo signal much more gradual than shown in this figure.

(*b*) *Pointing Error in Azimuth Only and in Elevation Only.* The error signal resulting from a pointing error in azimuth only is shown in figure 181 (A). The error signal resulting from a pointing error in elevation only is shown in figure 181 (B). In figure 181, the reflector axis is viewed from a head-on point on the axis, so that the axis is represented as a dot at the center of the circle. The center of the beam is represented by another dot which makes a circle

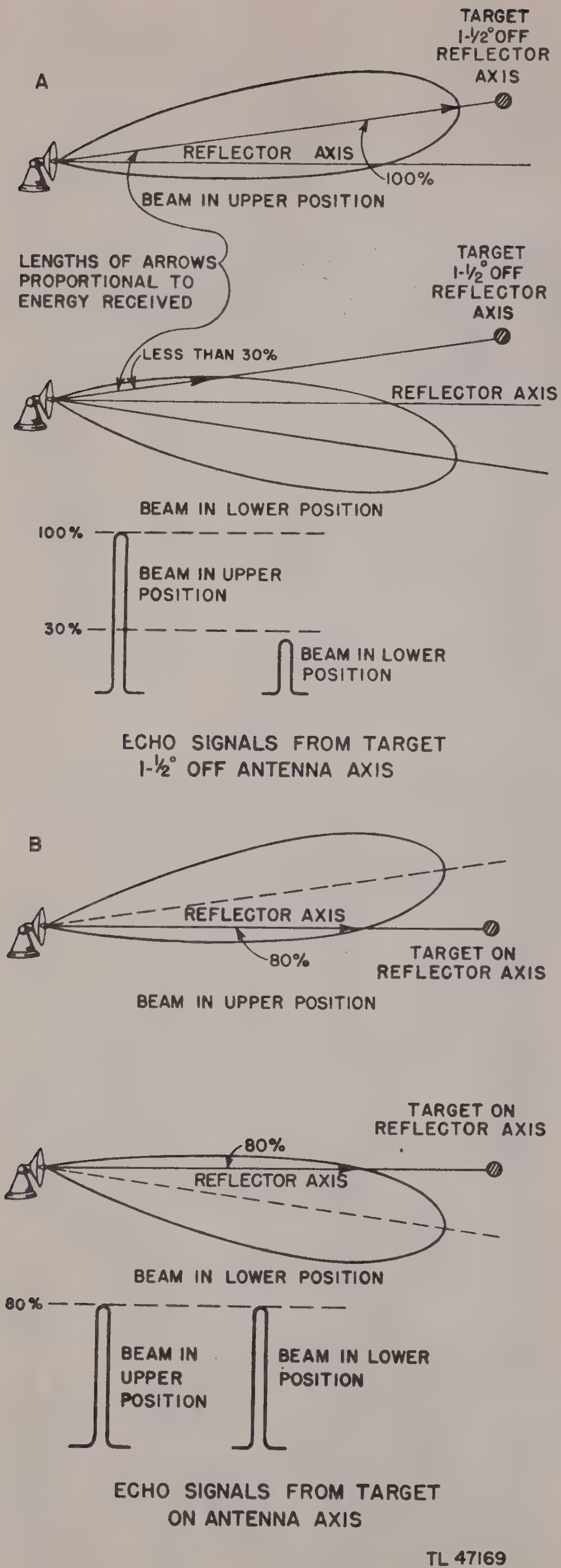

Figure 180. Echo signals produced by spinning antenna.

as the beam spins around the reflector axis. The target is represented by a small cross-hatched circle. The magnitude of the echo signal in the various positions of the beam is shown directly above the corresponding circular diagram which shows the beam position. A comparison of figure 181 (A) and figure 181 (B) shows that the error signal produced by a pure azimuth pointing error lags the error signal produced by a pure elevation pointing error by 90 degrees.

(*c*) *Pointing Error in Both Azimuth and Elevation.* The error signal produced when there is a pointing error in both azimuth and elevation is shown in figure 181 (C). As is to be expected, this error signal reaches maximum at a point between the maximum azimuth error signal and the maximum elevation error signal.

(*d*) *No Pointing Error.* When the axis of the reflector points directly at the target, the returning echo signals all have the same amplitude for every position of the beam as it rotates around the reflector axis and there is no pointing error. Figure 180 (B) shows the beam striking the target for the two special cases when the beam is above the target and when the beam is below the target, and shows that the target received 80 percent of the maximum beam energy. When the same situation applies for every other position of the beam, the reflected echoes always have 80 percent of maximum strength. When this occurs, there is no longer a 30-cycle modulated signal; but only the echo signal. This is the on-target position.

(2) *Production of Reference Voltages.* The azimuth and elevation reference voltages used in automatic tracking are produced by a reference voltage generator mounted on the coaxial line leading to the dipole. This generator spins with the dipole and is wound to produce two voltage outputs which are out-of-phase by exactly 90 degrees. Since the reference generator spins with the dipole at 30 revolutions per second, each of the reference voltage outputs from the generator is a 30-cycle sine wave. One revolution of the antenna produces one revolution of the antenna beam around the reflector axis. This produces one complete cycle of the error voltage, and at the same time the rotor of the reference generator makes one complete turn producing one complete cycle of each of the two reference voltages. The reference generator is so adjusted that as the generator rotates a positive maximum of the elevation reference

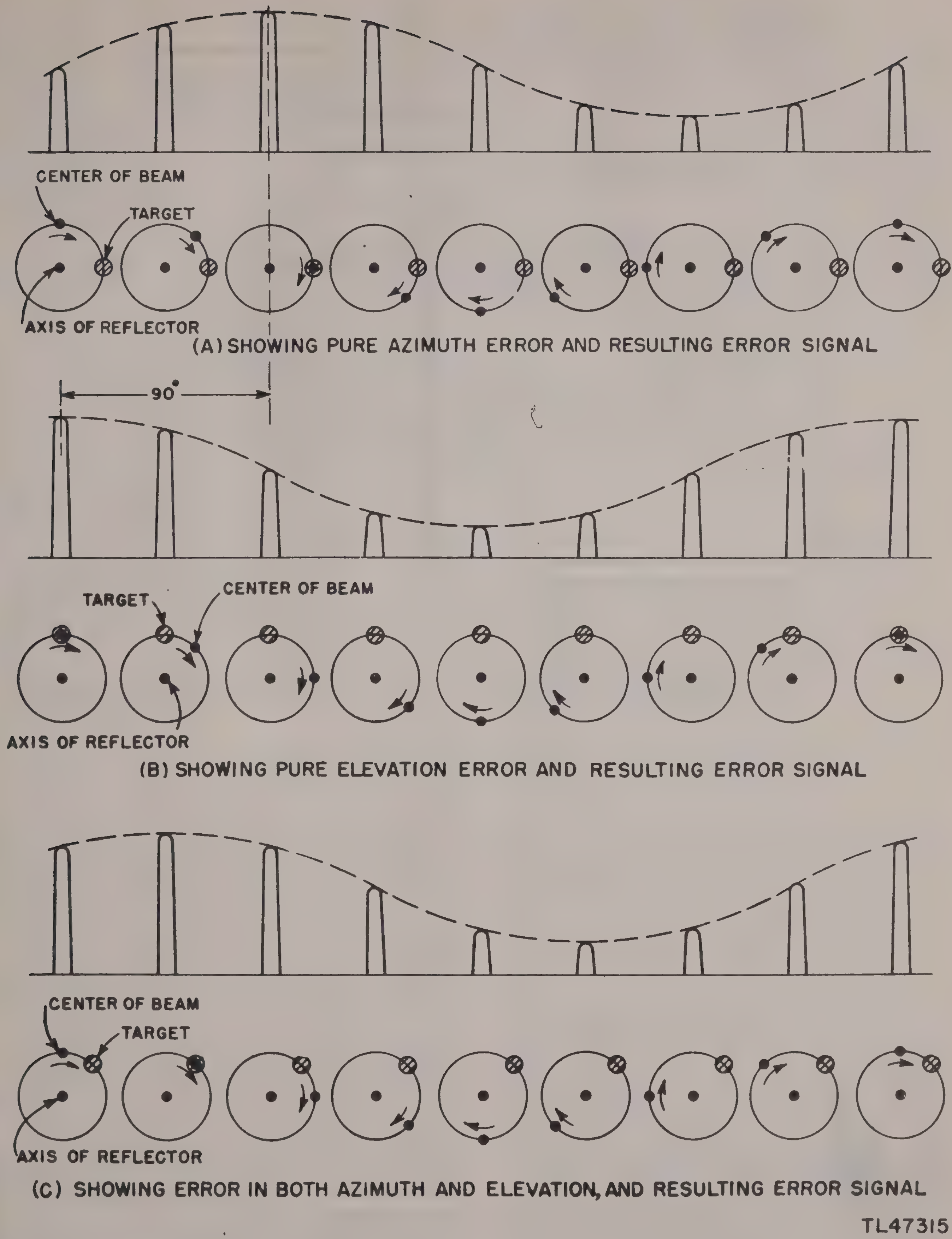

Figure 181. Signals produced by azimuth and elevation pointing errors.

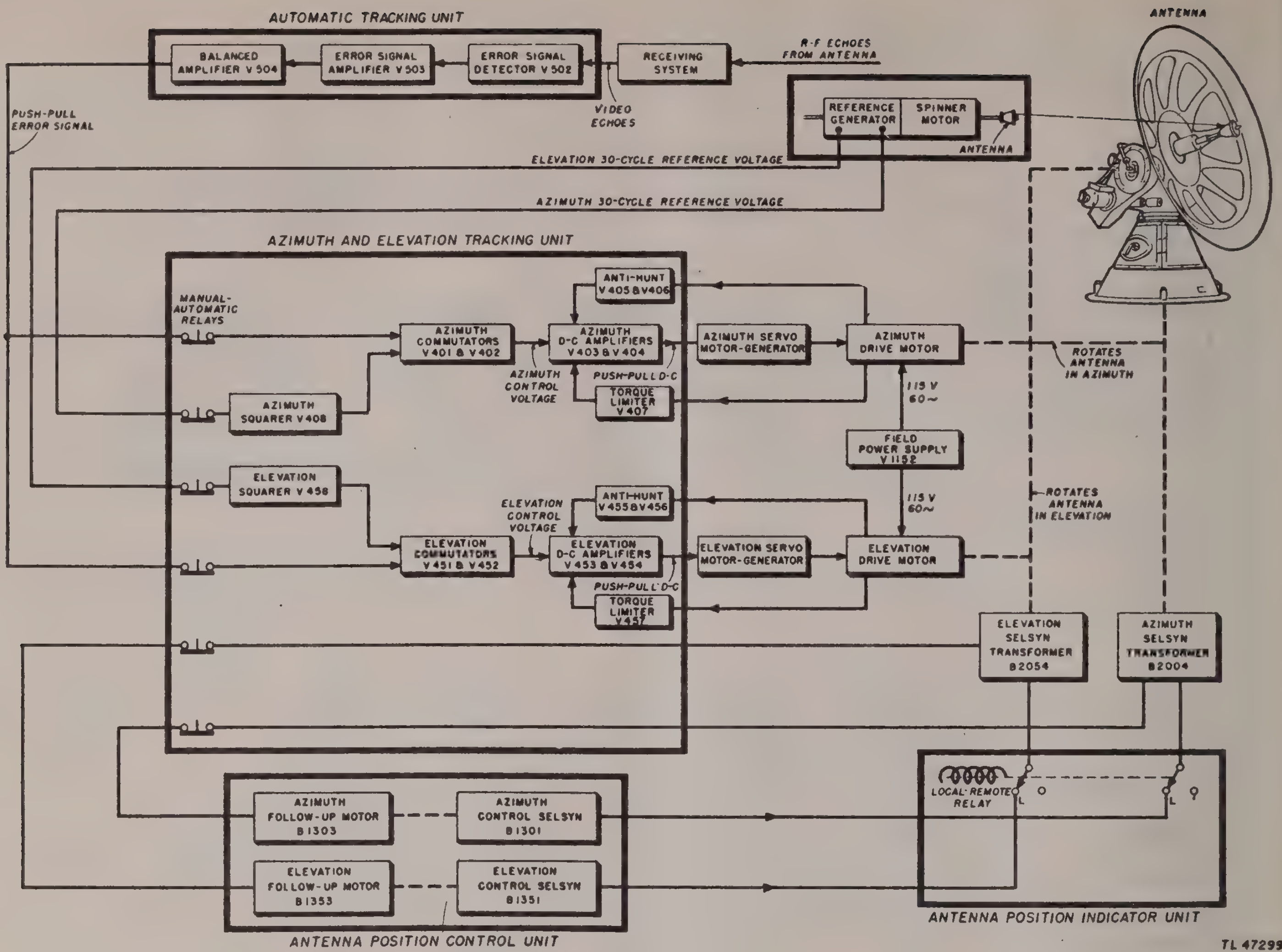

Figure 182. Automatic tracking system, block diagram.

voltage occurs when the beam of the antenna rotating dipole points at an upward angle in a plane perpendicular to the earth's surface and perpendicular to the reflector. The other (azimuth) reference voltage is exactly 90 degrees out-of-phase with this fixed elevation reference voltage.

(3) *Automatic Tracking Unit* (*fig. 182*). The video signals containing the error signal resulting from conical scanning is fed from the receiving system to a detector stage V502 in the automatic tracking unit called the error-signal detector (since it accomplishes the detection of the 30-cycle error signal from the video pulses). The error signal amplifier V503 produces a smooth sine wave proportional to the error signal. The balanced amplifier V504 amplifies the error signal and produces a push-pull output which is fed to the commutators of the azimuth and elevation tracking unit.

(4) *Azimuth and Elevation Tracking Unit* (*fig. 182*). The azimuth and elevation tracking unit is the unit which accepts the error signals and the reference voltages, and delivers a current to the motor generators which is proportional to the pointing error. This unit has two channels, one for azimuth and one for elevation. Each channel contains a squarer tube, two commutator tubes, two d-c amplifiers, an anti-hunt amplifier and limiter, and a torque limiter tube. In automatic operation, the squarer tubes receive the 30-cycle reference voltages from the reference generator, and develop a rectangular output which is fed to the plates of the commutator tubes. The commutator tubes receive the 30-cycle error signal from the automatic tracking unit and develop a d-c push-pull control voltage output. The polarity and magnitude of this d-c output depends on the strength of the error signal and its phase with respect to the reference voltage. Thus if the azimuth pointing error is such that the antenna must be rotated clockwise to bring it on target, the d-c control voltage is positive; if the pointing error is such that the antenna must be rotated counterclockwise to bring it on target, the d-c control voltage

is negative. The greater the azimuth pointing error, the greater this d-c control voltage. The output of the commutator tubes is fed to the d-c amplifiers. The d-c amplifiers develop a comparatively large current and feed this current to the field of the servo motor-generators, thus generating a voltage to drive the antenna drive motors. The anti-hunt tubes receive voltages from the drive motors, and these voltages are used to provide a feedback which makes the actions of the antenna smoother and more positive when coming to a new position. The inertia of the heavy antenna mount and the lag in the control circuits is capable of causing oscillations or hunting of the antenna in coming to its correct position; so the anti-hunt feedback is designed to overcome these effects and make the positioning of the antenna smooth, fast, and positive. The anti-hunt limiters prevent the anti-hunt action from becoming too strong by limiting the anti-hunt feedback voltage. The torque limiting tubes act on the d-c amplifiers to prevent them from ever sending too large a current into the motor generators. Extremely large currents would damage the driving mechanism by causing violent slewing and would overheat the electrical circuits. Like the anti-hunt circuit, the torque limiter circuit operates on the feedback principle. A voltage from the drive motor is fed back to the d-c amplifier to limit the torque which can be applied to the drive motor.

(5) *Servo Motor-generators* (*fig. 182*). The azimuth and elevation motor generators are large power amplifiers driven at constant speed by a motor. The motor, generator, and exciter armatures are on the same shaft but the fields are entirely separate. The output of the motor generator is controlled in both amplitude and polarity by the current supplied to the exciter field from the d-c amplifiers. This output is sufficient to turn the drive motors.

(6) *Drive Motors and Field Power Supply* (*fig. 182*). The outputs of the servo motor-generators are used to control the drive motors which are geared to the shafts which position the antenna in azimuth and elevation. The direction of antenna movement thus depends on the polarity of the output of the motor generator and the antenna is caused to turn in the proper direction to bring it on target and eliminate the error signal. The field rectifier supplies power to the fields of the drive motors.

(7) *Selsyn Transformers* (*fig. 182*). The selsyn transformers on the mount are connected to the follow-up motors in the antenna position control unit during automatic operation. The follow-up motors position the rotor of the azimuth and elevation control selsyns so that these control selsyns follow the antenna in azimuth and elevation, and no error voltage results to slew the antenna when the CONTROL SWITCH is turned from the AUTOMATIC to the MANUAL position.

b. Manual Positioning. A block diagram of the circuits and components used in manual positioning is shown in figure 183. With the CONTROL SWITCH in the MANUAL, PPI SCAN, or REMOTE position, the positions of the manual-automatic relay contacts shown in figure 178 are in the down position, and the inputs to the azimuth and elevation commutator and squarer circuits are the 60-cycle reference voltages and the manual positioning voltage from the azimuth and elevation selsyn transformers.

(1) *Control Selsyns and Selsyn Transformers* (*fig. 183*). The control selsyns are ordinary selsyns which are located in the antenna position control unit. They are constructed mechanically so that either the rotor or stator can be turned. The stator windings of each control selsyn are connected to the stator windings of another selsyn on the pedestal called the selsyn transformer. The transformers are mounted in the pedestal and are geared to the pedestal. The term transformer may be confusing; actually, the selsyn transformers are just ordinary selsyns which are used as special kinds of transformers in this application. A detailed explanation of selsyn operation is given in paragraph 172. It is sufficient for the explanation of this block diagram to note that the stators of the control selsyns are each connected to the stator of the corresponding selsyn transformer so that a current in the stator of the control selsyn produces a current in the stator of the selsyn transformer and a resultant current in the rotor of the selsyn transformer.

(2) *Production of Error Signal* (*fig. 183*). Any movement of the azimuth or elevation handwheel on the antenna position control unit moves the rotor of the control selsyn which produces a current in the control selsyn stator. This current flows in the selsyn transformer stator, which causes a voltage to be induced in the selsyn transformer rotor thus producing an error (or positioning) voltage which is fed to the

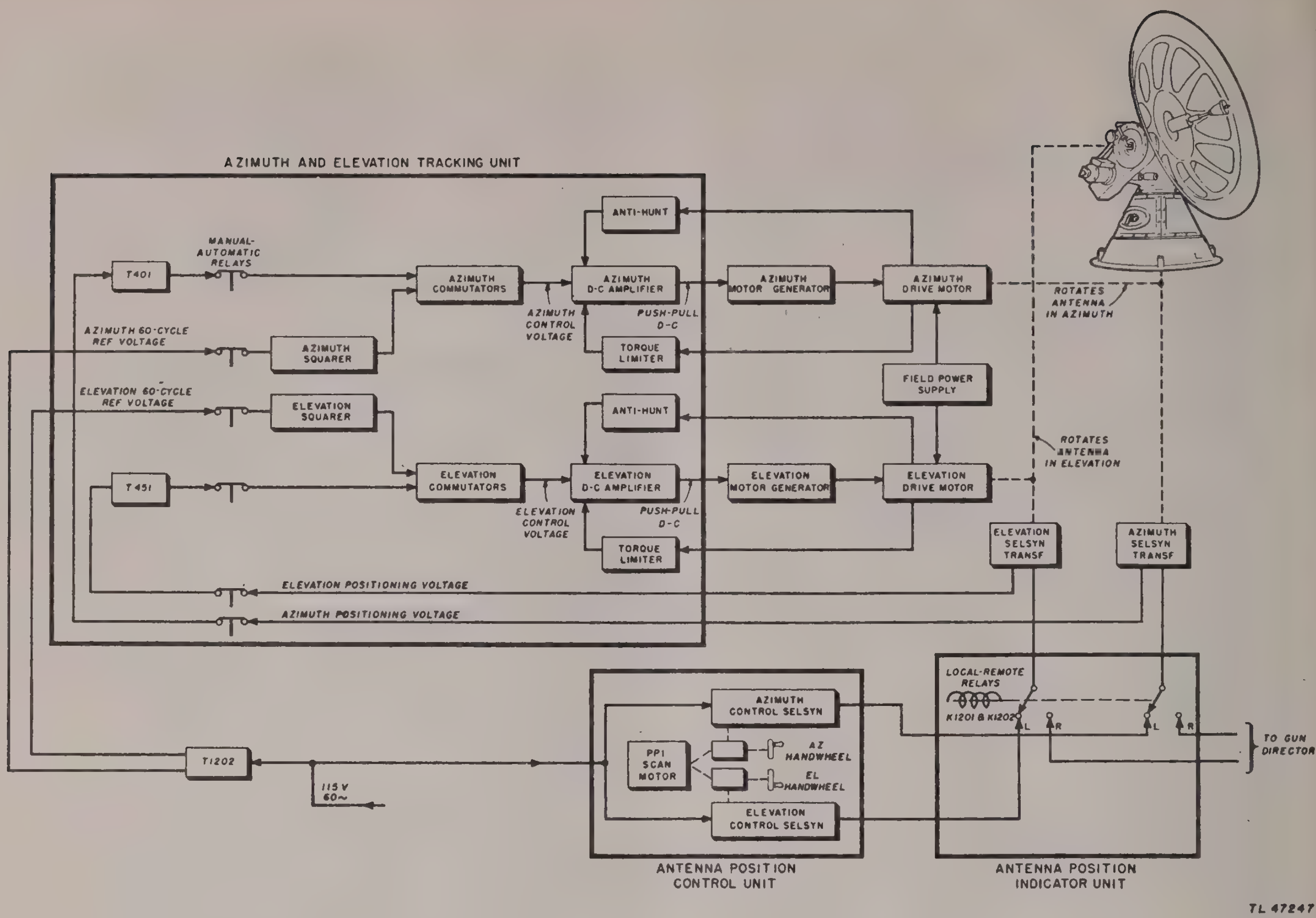

Figure 183. Manual positioning system, block diagram.

commutator tubes in the azimuth and elevation tracking unit. Note that for manual operation the local-remote relay in the antenna position indicator unit must be in the L (or local) position in order that the output of the control selsyns can be fed to the selsyn transformers. When the local-remote relays are in the R (or remote) position the input to the selsyn transformers is from the gun director. The PPI scan motor in the antenna position control unit is used to drive the control selsyns when the CONTROL SWITCH is in the PPI SCAN position. The scan motor acts in the same manner as the handwheels in that it turns the rotors of the control selsyns. Note that in manual positioning there are two separate error signal voltages, while in automatic operation the same error signal output of the automatic tracking unit serves for both the azimuth and elevation channels of the azimuth and elevation tracking unit. As this block diagram shows, the main difference in automatic and manual operation is the method of producing the error signals and the reference voltages. From the point where these error signals and reference voltages are fed to the squarers and commutators all four methods of positioning the antenna use the same circuit.

(3) *Local-remote Relays* (*fig. 183*). The two control selsyns and the two selsyn transformers are connected through the local-remote relays K1201 and K1202 in the antenna position indicator unit. These relays are controlled by the CONTROL SWITCH on the indicator-control panel. With the CONTROL SWITCH in the MANUAL position, the control selsyns are connected to the selsyn transformers in the pedestal. With the CONTROL SWITCH in the PPI SCAN position, the control selsyns are connected to the selsyn transformers, but the control selsyns are driven by the PPI scan motor. The PPI scan motor causes the azimuth control selsyn to make approximately 5 rpm while the elevation control selsyn is turned through 356 mils and returned to the starting elevation point. With the CONTROL SWITCH in the REMOTE position, the control selsyns are disconnected from the selsyn transformers

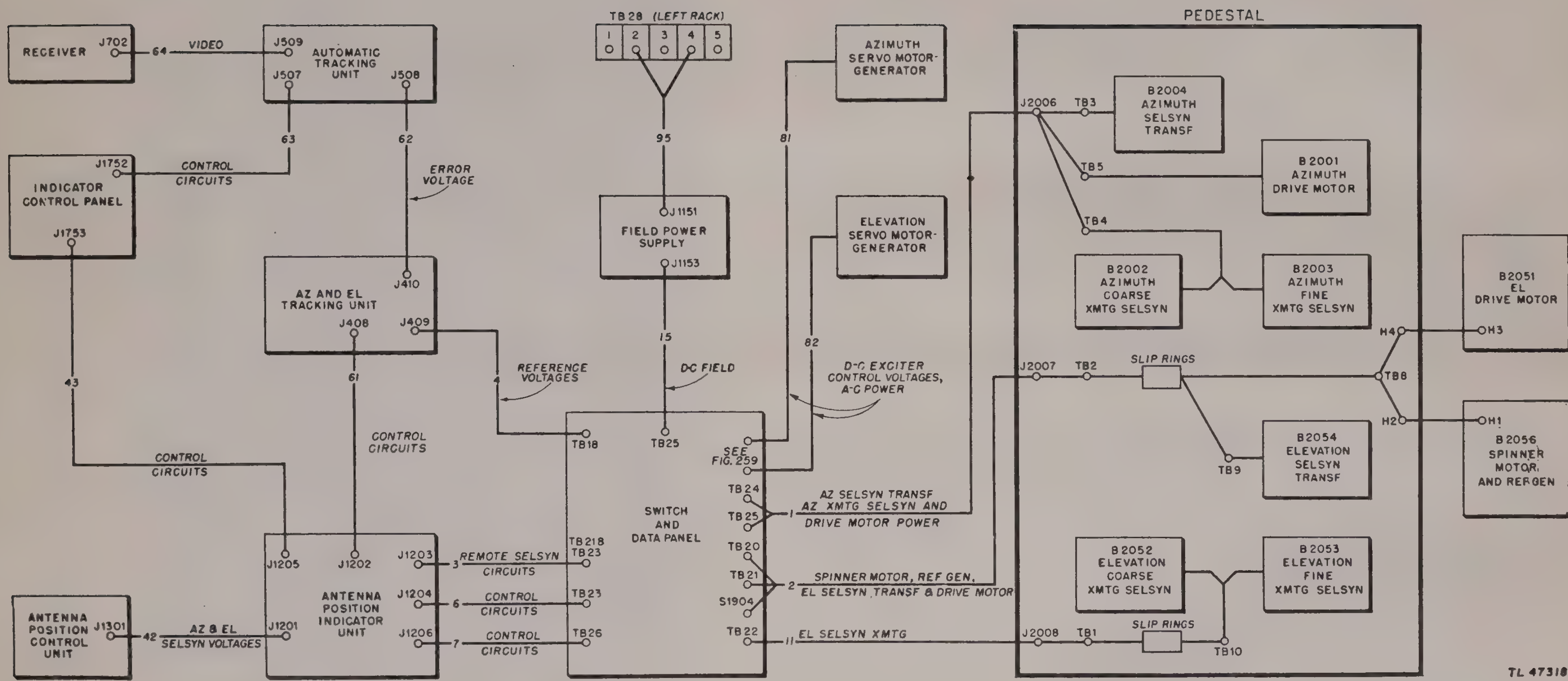

Figure 184. Antenna positioning system, cabling diagram.

and the selsyn transformers are connected to the transmitting selsyns in the gun director.

(4) *Manual-automatic Relays* (*fig. 183*). Transfer from automatic operation to manual positioning is effected by operation of the manual-automatic relays controlled by the CONTROL SWITCH. The switching done by these relays is at the inputs of the squarers and commutators and the circuits beyond the squarers and commutators function in exactly the same way in both automatic operation and manual positioning. In switching from automatic to manual, the input to the commutators is switched from the 30-cycle error signal from the automatic tracking unit to the 60-cycle error signal from the selsyn transformers, and the input to the squarers is switched from the 30-cycle reference voltage from the reference generator to the 60-cycle reference voltage from the 60-cycle a-c line.

161. CABLING.

A cabling diagram of the antenna positioning system is shown in figure 184. This diagram shows the physical connections between the various units employed in the antenna positioning system, gives the numbers of all cables and jacks, and is helpful to the trouble shooter. The receiver and the automatic tracking unit are a part of the antenna positioning system during automatic operation only. All the other units which are in the antenna positioning system are a part of the system in all the operating positions. Figure 184 shows the major circuits carried in each cable. For detailed cabling connections in the switch and data panel and the antenna pedestal, see figure 260.

SECTION II

AUTOMATIC TRACKING UNIT

162. INTRODUCTION.

A front view of the automatic tracking unit is shown in figure 185, and a top view showing the location of the various stages in figure 186. This unit contains the circuits to detect the video echoes so as to produce the 30-cycle error signal necessary to produce the azimuth and elevation control voltages which keep the antenna positioned on target. The power supply for this unit and for the azimuth and elevation tracking unit is also contained in the automatic tracking unit. The general functioning of the automatic tracking unit is shown in the block diagram in figure 187 and a complete schematic diagram is shown in figure 212.

163. OPERATION.

a. Detection Circuit. The primary purpose of the automatic tracking unit is to detect the video echoes so as to produce the 30-cycle error signal.

(*1*) This video detection is accomplished by the error signal detector V502 and the R-C circuit formed by resistor R504 and capacitor C502 (fig. 188). The negative video pulses modulated with the 30-cycle error signal are applied to the cathode of V502 across resistor R502 and through resistor R501. The voltage at the plate of V502 tends to follow the peak height of the video signals, since capacitor C502 charges at a fast rate (through the tube) during the pulse but discharges at a slow rate (through the 1-megohm resistor R504) between pulses. This is shown in the wave of output voltage of the R-C circuit in figure 189 (B). Note that the slope of the charge curve is much steeper than the slope of the discharge wave.

(*2*) In paragraph 160**a** (*1*) the reference voltages were in phase with pure azimuth and elevation error voltages. Figure 189 shows that the peaks of the three waves represented there do not fall underneath each other, because of phase shifts that occur between stages.

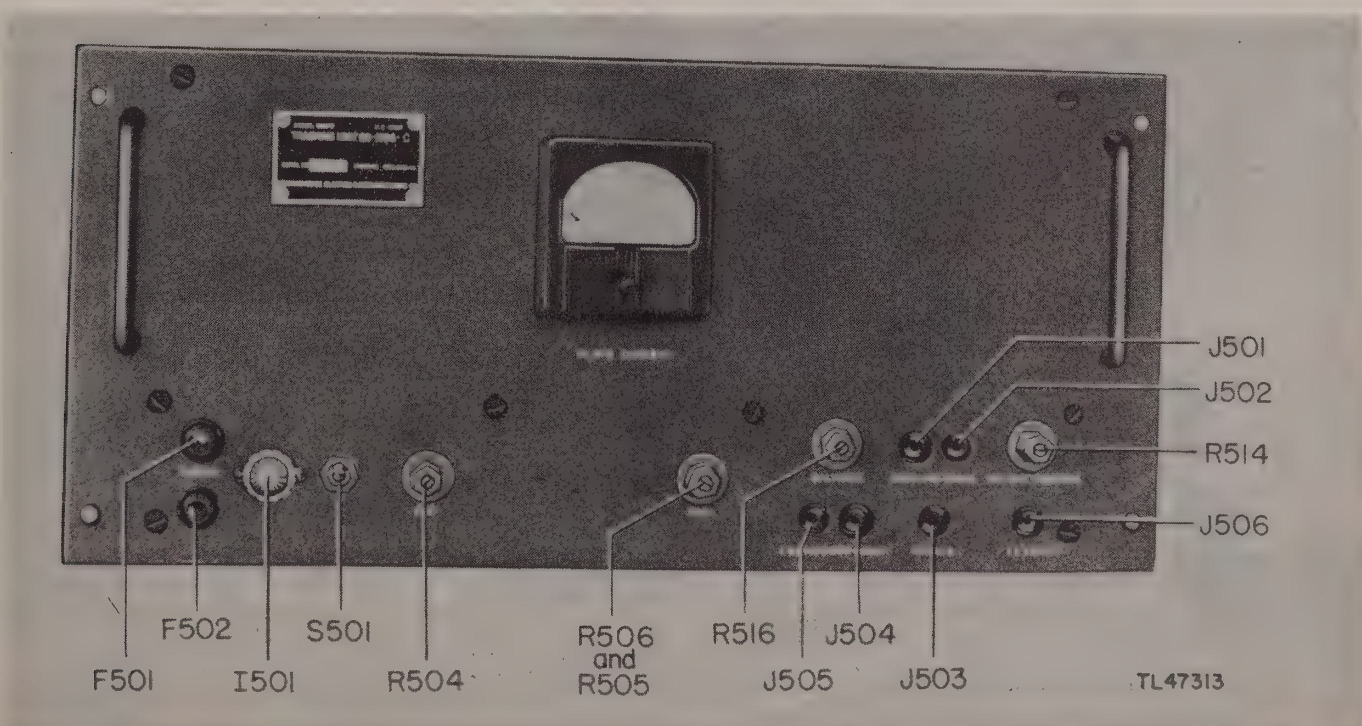

Figure 185. Automatic tracking unit, front view.

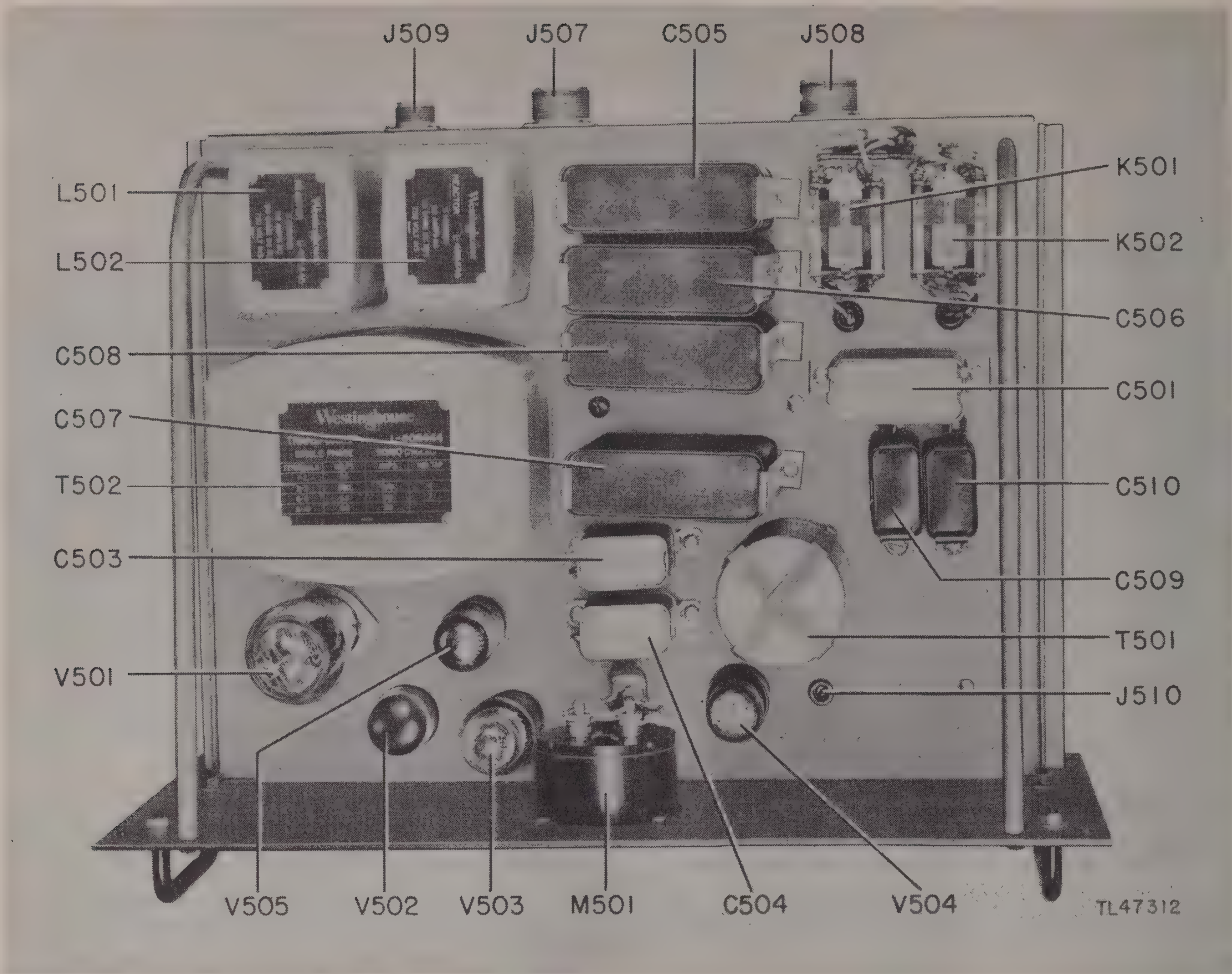

Figure 186. Automatic tracking unit, top view.

This causes no trouble as long as the phase shifts remain constant since the phase of the reference voltages is set with respect to the error signal regardless of how much this error signal may lag the modulation on the echo signals. The phase of the reference voltage with respect to the pure azimuth and error voltage can be varied by shifting the field of the reference generator. Figure 189 shows the input to V502, the output of the detection circuit, and the output of transformer T501.

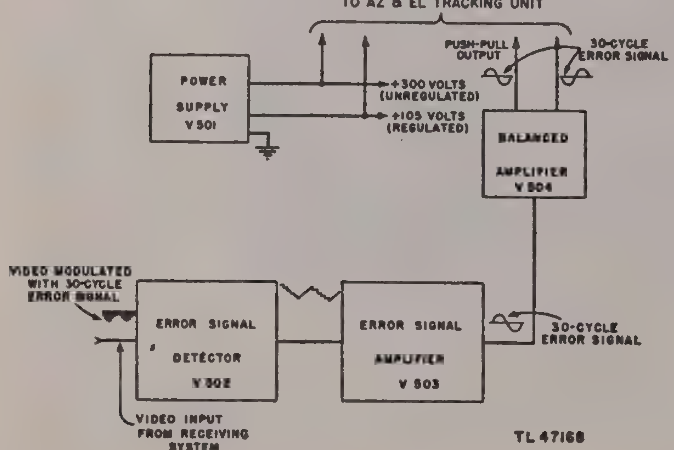

Figure 187. Automatic tracking unit, block diagram.

b. Error Signal Amplifier.

(*1*) Amplifier V503 has an automatic volume-control action. The output of the detection circuit is fed to the control grid of V503 (fig. 212) at a negative d-c level which averages

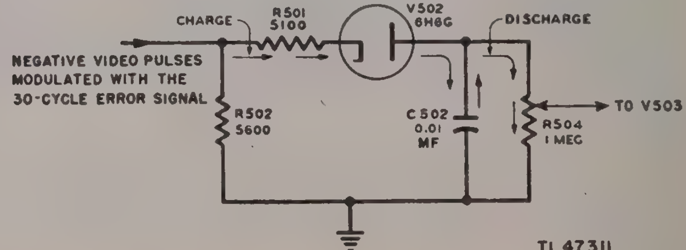

Figure 188. Error signal detector, simplified schematic diagram.

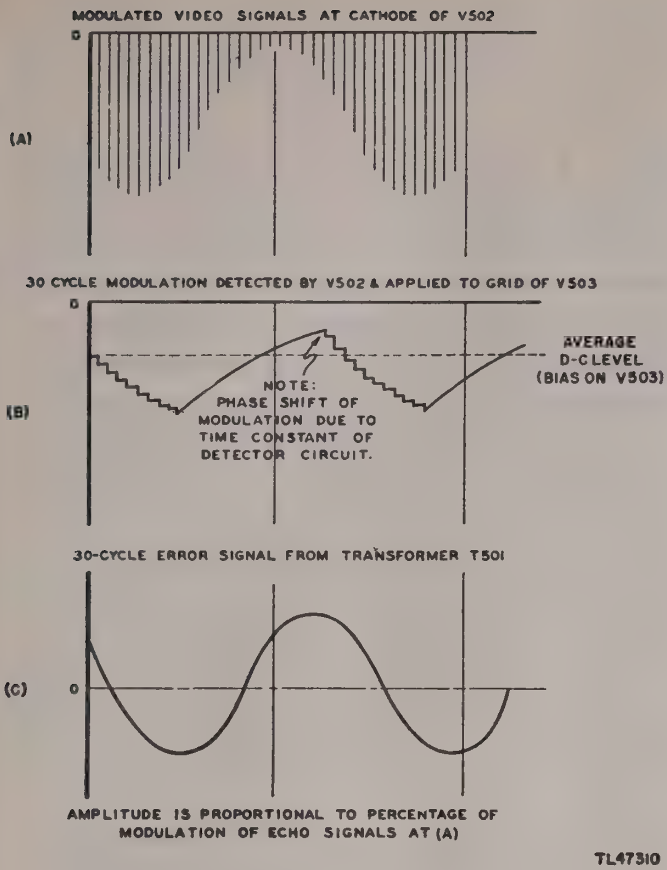

Figure 189. Error signal waveforms.

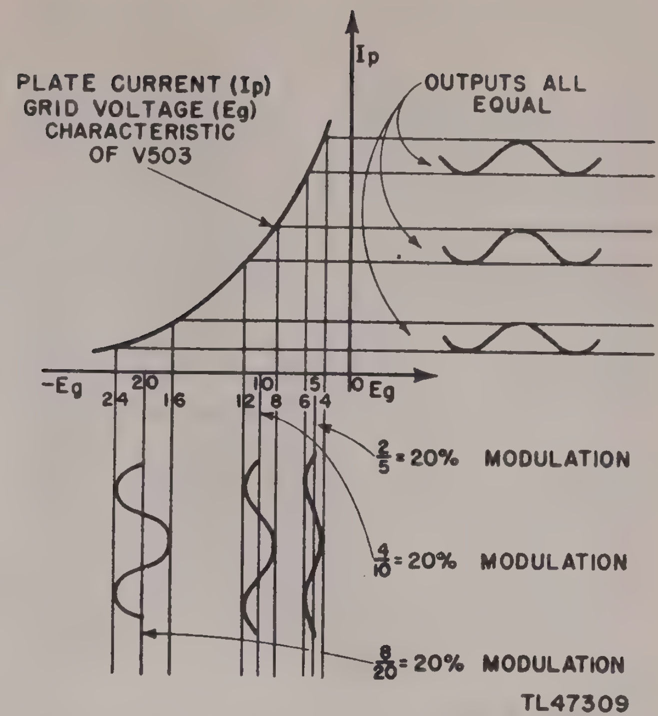

Figure 190. Automatic control action of error signal amplifier.

about 6 volts. The characteristics of V503 are such that more bias (brought about by the reception of a stronger signal) results in a decrease in the gain of the amplifier as shown in figure 190. The reception of weaker signals results in less bias and an increase in the gain of the amplifier. The result is that the magnitude of the error signal in the plate circuit of the amplifier is practically independent of the average pulse height and depends only on the percentage of modulation present in the modulated video signals. Thus, as shown in figure 190, the output would be approximately the same if the input varied from 4 to 6, 8 to 12, or 16 to 24. In each case, the percentage of modulation is 20 percent. This action takes care of rapid fluctuations in the average intensity of the echo signals which the AGC of the receiver is not designed to follow.

(*2*) To adjust the operating point so that the required portion of the tube characteristic is used, the AVC control on the panel should be set so that meter M501 reads 6 milliamperes with the antenna directed at a fixed target, and the CONTROL SWITCH set to the AUTOMATIC position.

(*3*) The output of V503 is fed to the coupling transformer T501 (fig. 212). Since the output of the coupling transformer is determined by the a-c component of the plate current of V503, the transformer output is a 30-cycle error signal of a phase determined by the direction of the target from the axis of the reflector and with a magnitude proportional to the pointing error. Transformer T501 is tuned to 38 cycles by an R-C network consisting of resistor R503 and capacitors C503 and C504. This network tends to eliminate any higher frequencies contained in the modulation and produces a practically smooth 30-cycle sine-wave error signal even though a distorted 30-cycle sine wave flows in the primary of T501.

c. Balanced Amplifier. The output of transformer T501 is applied to the grids of the balanced amplifier V504 (fig. 212) by potentiometers R505 and R506 which act as voltage dividers to allow adjustment of the amount of input to V504. Both potentiometers are adjusted by the GAIN control on the panel of the automatic tracking unit. Resistors R509 and R510 limit the amount of current that can be drawn by the grids of V504. The cathodes of V504 are connected together. Cathode bias is obtained through potentiometer R514 which is the VOLTAGE CONTROL on the front panel of the

automatic tracking unit. Potentiometer R514 should be set to obtain 2.9 volts on the cathode of V504. Plate voltage for the two halves of V504 is supplied through potentiometer R516 which is the BALANCE control on the front panel. Potentiometer R516 compensates for any unbalance in the two halves of V504 by changing the voltage on the plates. When the BALANCE control is set properly, the outputs of the two halves of the balance amplifier are equal. This control is set so that the meters in the azimuth and elevation tracking unit are equal, with no signal in the narrow gate and with the CONTROL SWITCH in the AUTOMATIC position. The push-pull signal output of the balanced amplifier is the input to the azimuth and elevation tracking unit, where it serves as the error signal when the equipment is in automatic operation.

d. Coast Relay.

(*1*) Under certain conditions it is desirable to reduce the error signal to zero. This is done by shorting the output of transformer T501 to ground through contacts 1 and 2 and 4 and 5 of the coast relay K501 (fig. 212). Relay K501 is energized by 115 volts ac when the COAST button on the indicator-control panel is depressed.

(*2*) The coast feature is used when tracking a plane and another plane crosses the path of the plane being tracked. Under these conditions, two echo signals would appear at the same time in the narrow gate which determines the output of the receiver to the automatic tracking unit. If the automatic tracking circuits were allowed to continue functioning, automatic tracking would be interfered with, since the antenna would attempt to follow both planes. The COAST button energizes relay K501 and overcomes this difficulty by artificially reducing the error signal to zero. The antenna continues to follow the target for about 4 seconds because of the inertia of the system. In this length of time, the interfering plane would in all probability be far enough away from the target plane so that the interfering echo signal would not appear in the narrow gate. The COAST feature is used also in checking for drift, and to cope with intermittent distortion of the error signal by other radar equipments operating in the vicinity.

e. Power Supply. The ON-OFF switch S501 located on the front of the panel of the automatic tracking unit applies a-c voltage to the power supply. Power transformer T502 (fig. 212) supplies filament and plate voltage for the full-wave rectifier V501, and 6.3 volts for the filaments of the other tubes. Pilot light I501, is connected across the 6.3-volt winding and when

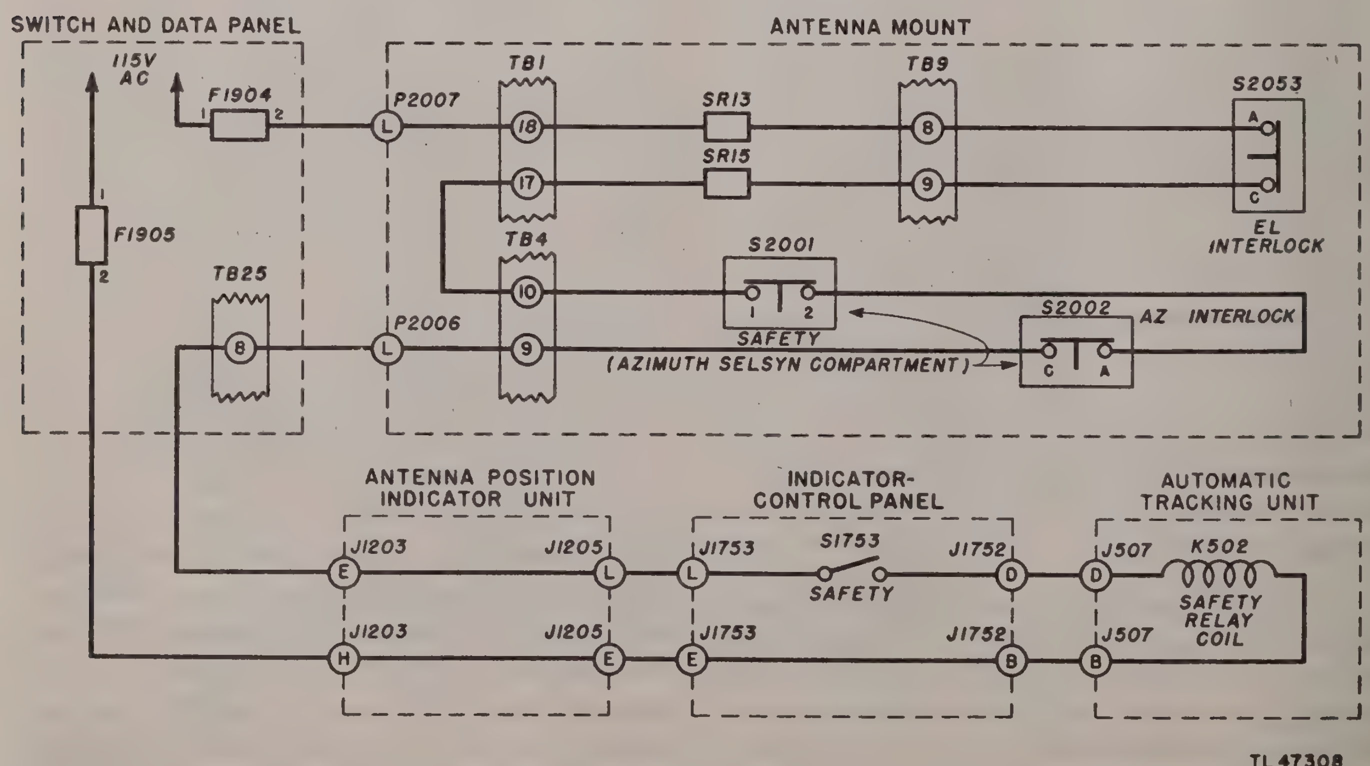

Figure 191. Safety relay interlock, schematic diagram.

lighted indicates that the transformer is receiving 115-volt a-c power. The 300-volt output of rectifier V501 is filtered by a two-section choke-input filter composed of coils L501 and L502, and capacitors C505 and C506. A voltage divider composed of resistors R522 and R523 provides +75 volts to jack J506 and to the center taps of transformers T401 and T451 in the azimuth and elevation tracking unit. The VR-105-30 voltage regulator tube V505 provides screen grid voltage for V503. The 300-volt output of this power supply also supplies plate and screen grid voltages for the azimuth and elevation tracking unit.

f. Safety Relay. Safety relay K502 is de-energized by any one of the safety switches and interlocks shown in the safety relay interlock circuit (fig. 191). The purpose of relay K502 is to prevent injury to personnel and equipment when work is being done on the pedestal. When relay K502 is de-energized, the 300-volt supply is removed from the azimuth and elevation tracking unit, motion of the pedestal stops almost instantly and is not resumed until the relay is re-energized.

SECTION III

AZIMUTH AND ELEVATION TRACKING UNIT

164. INTRODUCTION.

The azimuth and elevation tracking unit is used for both automatic and manual tracking and the circuit operation is the same for both methods. This unit takes the error voltage from the automatic tracking unit and the reference voltage from the reference generator, develops an output proportional to the magnitude of the error voltage, and feeds this output to the azimuth and elevation servo motor-generators. The two meters on the unit read the output push-pull current of the d-c amplifier stages in either the azimuth or elevation channel. The position of the AZIMUTH-ELEVATION switch on the front panel determines which channel the meters read. Figure 192 shows the front view of the azimuth and elevation tracking unit, and figure 193 shows the top view. The unit is divided into two channels. As viewed from the front, the elevation channel is on the left and the azimuth channel is on the right. The complete schematic diagram of the azimuth and elevation tracking unit is given in figure 213.

165. OPERATION.

a. Squarer and Commutator Circuit (fig. 194).

(*1*) *General.* A simplified schematic diagram which shows the commutator tubes and squarer tube in the azimuth tracking circuit is shown in figure 194. A similar group of tubes comprises the elevation squarer and commutator circuit. The function of the commutator tubes is to provide a d-c potential which is proportional to the product of the error signal and the cosine of the angle of phase shift between the error signal and the reference voltage. The error signal in automatic operation is the 30-cycle push-pull error signal from the automatic tracking unit. In PPI, manual, or remote operation, the error signal is the 60-cycle positioning signal from the azimuth selsyn transformer. In automatic operation, the same error signal is applied to the grids of both the azimuth and elevation commutator tubes, but the reference voltages for the azimuth squarer tube and the elevation squarer tube are 90 degrees out-of-phase. For the sake of clarity, the two triode sections of the tubes in figure

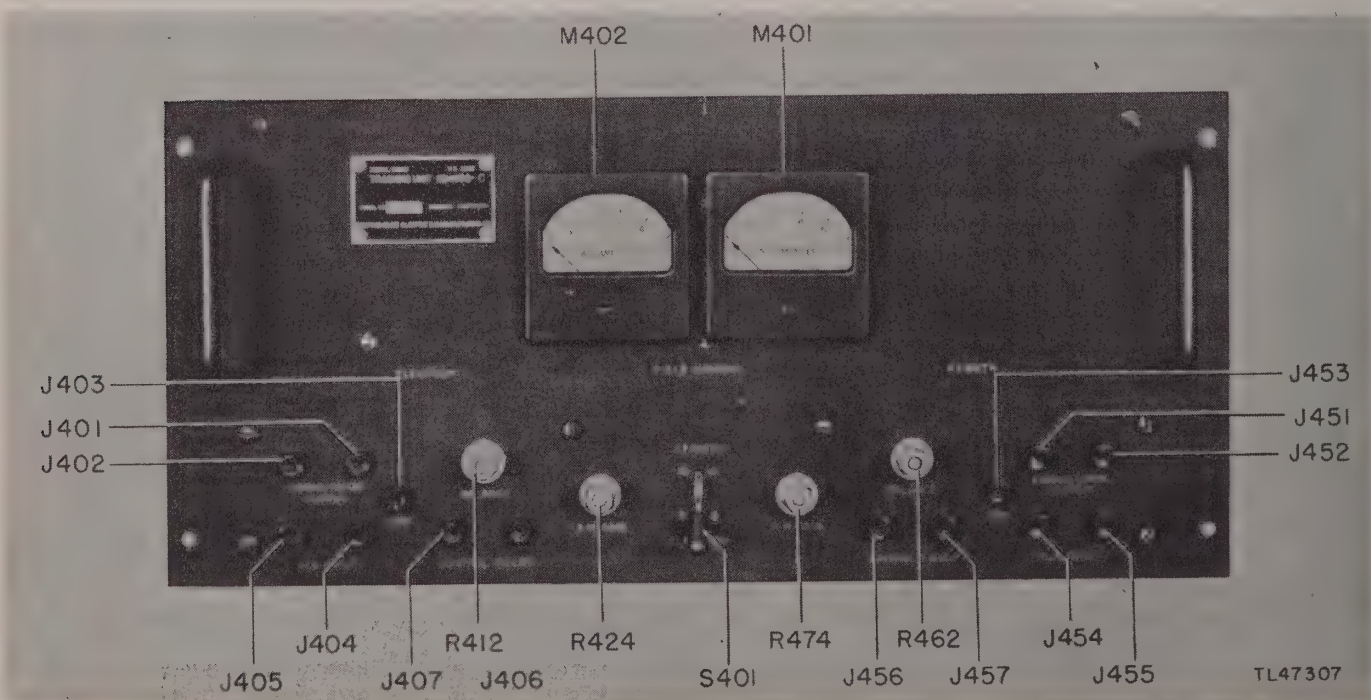

Figure 192. Azimuth and elevation tracking unit, front view.

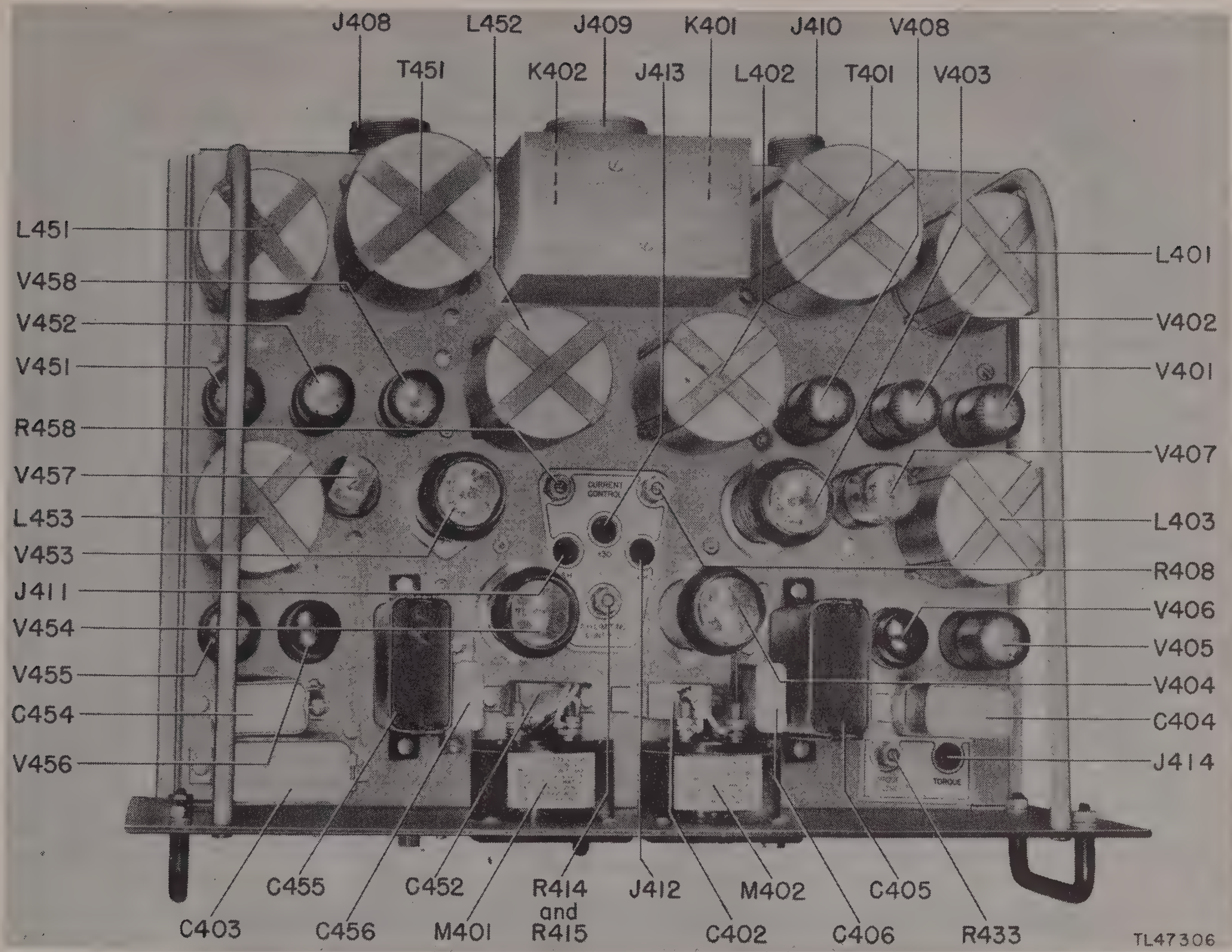

Figure 193. Azimuth and elevation tracking unit, top view.

194 have been separated in order to make the diagram easer to follow. In automatic operation the push-pull 30-cycle reference voltage is applied to the primary of the azimuth reference transformer T1901 in the switch and data panel. From the secondary of T1901 is taken a push-pull reference voltage which is applied across the grids of the two sections of the azimuth squarer tube V408. These two sections are operated at zero bias because the center tap of transformer T1901 and cathodes are grounded. During the first half of the reference voltage cycle, the negative component of the reference voltage is sufficient to drive the left-hand section of V408 to cut-off, while the positive component drives the right-hand section of the tube to saturation where a small grid current is drawn, because of the series grid resistor R432. The value of the plate resistors plus the normal load of the three tubes is such that the voltage appearing at the plates of all the tubes is about 150 volts positive. When the left-hand section of V408 is driven to cut-off, there is no drop in plate voltage from the 150 volts supplied. Consequently, the voltage supplied to the plates of the left-hand sections of V401 and V402 is 150 volts. When the right-hand section of V408 is driven to saturation, the increase in plate current through the plate resistors R427 and R428 causes a drop in plate voltage to 90 volts. Consequently, the voltage applied to the plates of the right-hand sections of V401 and V402 is 90 volts, which, because of the cathode biasing, cut off these right-hand sections of V401 and V402. Consequently, looking at the circuit composed of the right-hand sections of the three tubes (fig. 194) it is seen that when the voltage on grid G5 of V408 is the positive component of the reference voltage, that this section of V408 is driven to saturation and the plate voltage appearing at plates P2, P4, and P5 drops to about 90 volts. This means that the right-hand sections of V401 and V402 are cut off. At this same instant, the left-hand section of V408 is cut off, and the plate voltage appearing at plates P1, P3, and P6 is 150 volts. The left-hand sections

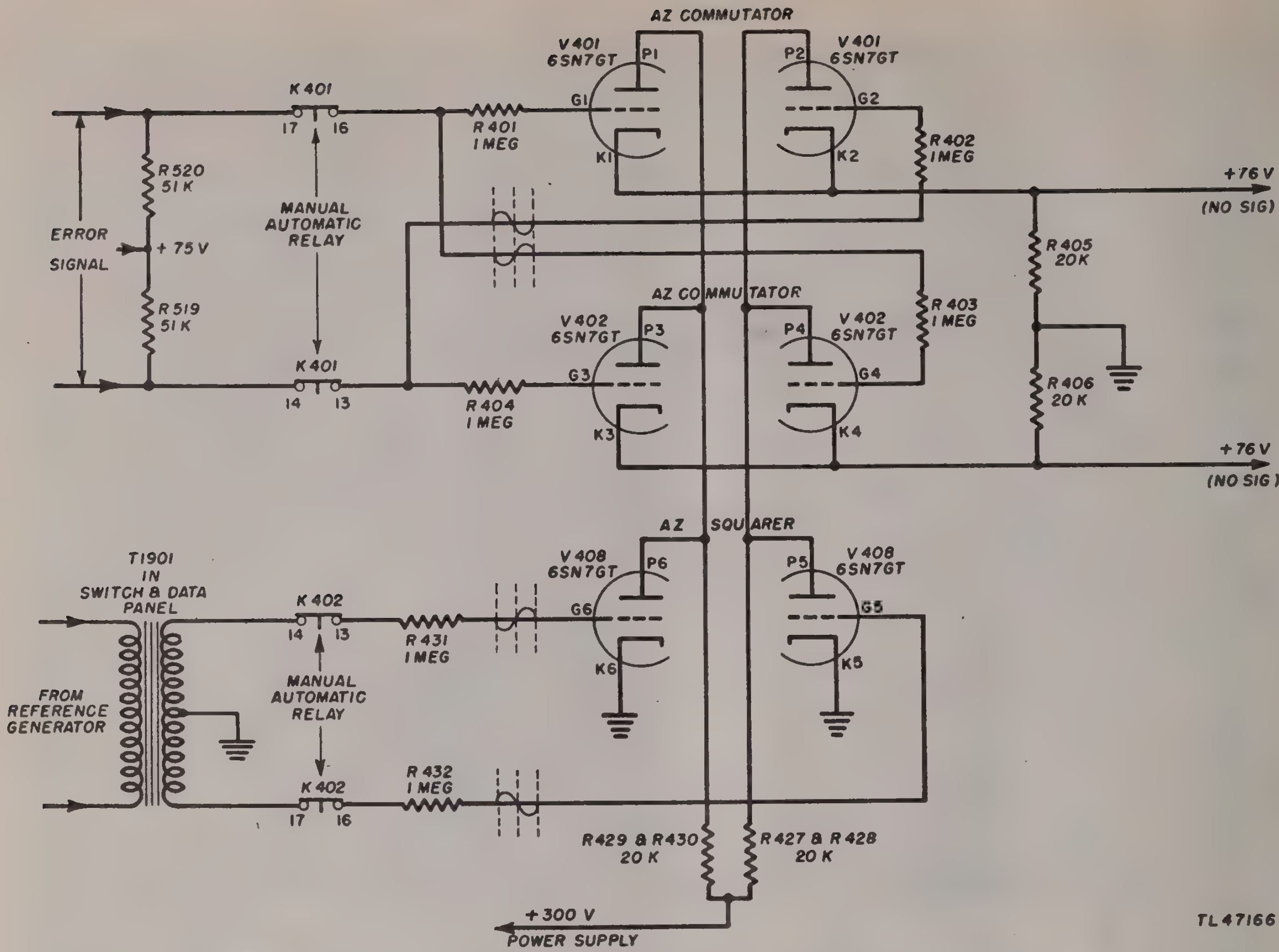

Figure 194. Squarer and commutator circuit, simplified schematic diagram.

of V401 and V402 react to signals applied to the grids, and, because of the cathode load connections of the tubes, these sections act as cathode followers. During the succeeding half-cycle of reference voltage the opposite sections of the two tubes V401 and V402 have a high plate voltage and conduct, whereas the sections which were formerly conducting are driven to cut-off. Thus it can be seen that the function of the reference voltage is to maintain one leg of the circuit in an operative condition to function with the error signal during 180 degrees and to cut this leg off and place the other leg in operation during the succeeding 180 degrees of the reference voltage.

(2) *No Error Signal.* The plates of the squarer are directly connected to the plates of the commutator tubes (fig. 194). Thus, with no error signal input applied to the grids of V401 and V402, one half of each commutator tube is conducting while the other half is completely cut off. The characteristics of a 6SN7 are such that a plate voltage of 150 volts and a grid voltage of 75 volts (bias level supplied from the automatic tracking unit) results in a cathode voltage of 76 volts across the 20,000-ohm cathode resistors R405 and R406. Since the two cathodes of each commutator tube are connected together, and one half of each tube is conducting at any instant, the result is a steady cathode output of 76 volts. Keep in mind that the operation just described is with no error signal applied.

(3) *Error Signal in Phase with Reference Voltage.*

(*a*) The application of an error signal to the grids of V401 and V402 while the reference voltage is applied to the grids of V408 causes the circuit to produce a difference in cathode potentials of V401 and V402, the cathodes of one tube assuming a potential more positive than the cathodes of the other tubes. This creates a voltage differential between the two cathodes which may be amplified and applied to the excitation field of the servo motor-generator to control the positioning of the antenna. Furthermore, the functioning of the circuit is such that the phase relationship between the reference voltage and the error

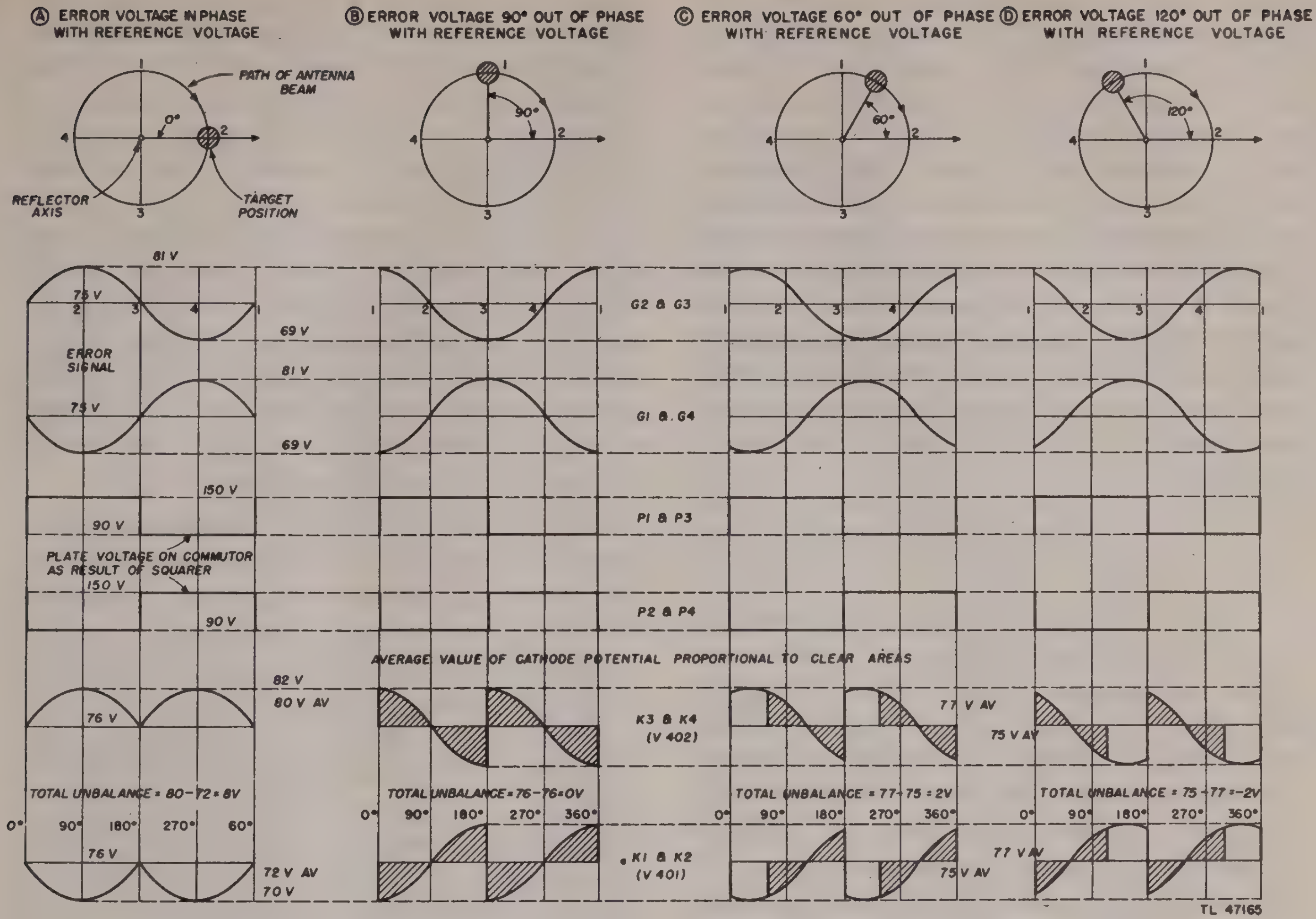

Figure 195. Squarer and commutator circuit, waveforms.

signal determines the polarity of the voltage differential between the cathodes of V401 and V402. The magnitude of the error signal is translated by the circuit into a corresponding voltage magnitude existing between the two cathodes.

(*b*) Refer to figures 194 and 195. When an error signal in phase with the push-pull azimuth reference voltage is applied to the grids of V401 and V402 (the azimuth commutator tubes), it represents the condition that exists in the azimuth tracking circuit when there is a pointing error in pure azimuth and no pointing error in elevation, and is the condition illustrated by the waveforms in figure 195 (A). During the first half of the cycle; grids G1 and G4 are driven negative, and grids G3 and G2 are driven positive. The negative component of the reference voltage has driven grid G6 to cut-off, raising plates P1, P3, and P6 to 150 volts, and causing the left-hand sections of V401 and V402 to conduct. The positive component of the reference voltage has raised the voltage on grid G5 enough to lower plates P2, P4, and P5 to the point where the right-hand sections of V401 and V402 are cut off. Since G3 is in its positive half-cycle and G1 is in its negative half-cycle, there is an increase of current in R406 with respect to the condition of no error signal (subpar. (*2*) above), and the potential across R406 becomes more than 76 volts, while there is a decrease of current in R405 and the potential across R405 becomes less than 76 volts. The potential on cathodes K3 and K4 rises and the potential of cathodes K1 and K2 falls.

(*c*) On the next half-cycle plates P1 and P3 are at 90 volts and the left-hand sections of V401 and V402 are cut off. Now only the voltages on grids G2 and G4 influence the current in the commutator tubes. Grid G4 is in its positive half-cycle and G2 is in its negative half-cycle, so that again there is an increase of current through R406 over the no-error-signal condition and a decrease through resistor R405. Thus the cathode voltages follow the same curve they followed in the first half-cycle.

(*d*) Because of the difference in the currents through resistors R405 and R406, the average potential of the cathodes of V402 are higher than the average potential of the cathodes

of V401. The current changes take place at 30 cycles, but the input filter circuits to the grids of the d-c amplifier tubes produce d-c voltages equal to the average value of the varying voltages on the cathodes of the commutator tubes. Bear in mind that the error signal just discussed was in phase with the reference voltage, but if it had been 180 degrees out-of-phase with the reference voltage the average potential across resistor R405 would be greater than 76 volts and the average potential across resistor R406 would be less than 76 volts. The voltage differential would be of the same value as for the in-phase condition, but note that it would be of opposite polarity.

(*4*) *Error Signal 90° Out-of-phase with Reference Voltage.*

(*a*) The condition in which the error signal is 90 degrees out-of-phase with the reference voltage is described with the aid of figure 195 (B). At the start of the cycle, the right-hand sections of V401 and V402 are cut off (because they are at 90 volts and will not reach 150 volts until 90° later), and the left-hand sections are conducting (because they are at 150 volts and will not cut off until 90° later). Therefore, G1 and G3 are the controlling grids and the cathode voltage of V401 is minimum, while the cathode voltage of V402 is maximum. At the 90-degree point, grid G1 swings positive and grid G3 swings negative, and the cathodes follow the grids until the cathode voltage of V401 is maximum while the cathode voltage of V402 is minimum. At the 180-degree point, the right-hand sections of V401 and V402 suddenly become conducting, while the left-hand sections are suddenly cut off. This switch is due to the change of plate voltages as a result of the squarer tube. Now G2 and G4 become the controlling grids. Since the voltage on G4 is at its maximum and the voltage on G2 at its minimum, the voltage at the cathode of V402 rises sharply to a maximum and the voltage on the cathode of V401 falls abruptly to its minimum. At the 270-degree point G2 and G4 continue as the controlling grids, and the cathode voltages follow them, the cathode voltage of V402 ending on a minimum, and that of V401 ending on a maximum.

(*b*) Figure 195 (B) shows that the average value of both cathode voltages is 76 volts (the same as the value obtained with no error voltage on the grids), since the curve is above and below the d-c level for equal intervals. This means that zero control voltage is produced because this condition (in which the error voltage is 90 degrees out-of-phase with the reference voltage) is the condition that exists when there is a pointing error in azimuth and no pointing error in elevation, or the condition that exists when there is a pointing error in elevation and no pointing error in azimuth. The two reference voltages are always 90 degrees out-of-phase; so an error signal 90 degrees out-of-phase with one of these reference voltages is either in phase or 180 degrees out-of-phase with the other reference voltage, with the result that there is antenna movement in one direction only.

(*5*) *Error Signal 60° Out-of-phase with Reference Voltage.* The operation of the commutator tubes was explained in subparagraphs (*2*), (*3*), and (*4*) above. Therefore, for the 60-degree condition, it is sufficient to trace out the curve of cathode voltages on V401 and V402 in figure 195 (C). The cathode voltage of V401 starts to follow the curve of G1 and reaches its minimum at 30 degrees while the cathode voltage of V402 follows the curve of G3 and reaches its maximum at 30 degrees. The cathodes continue to follow the curves of grids G1 and G3 until the 180-degree point, where the right-hand sections of V401 and V402 become operative and the left-hand sections cut off. Now grids G2 and G4 become the controlling grids. Since G4 is going positive and G2 is going negative, the cathode voltage of V402 rises abruptly; the voltage at the cathode of V401 falls abruptly. Now the cathode voltages follow the curves of grids G2 and G4 with the cathode voltage of V401 reaching minimum at 210 degrees and the cathode voltage of V402 reaching maximum at 210 degrees. The cathode voltage follows G2 and G4 from this point to the end of the cycle. The average voltage on the cathode of V402 is greater than for the 90-degree out-of-phase condition, though it is not as high as for the in-phase condition. The average cathode voltage of V401, by the same reasoning, is less than the voltage for the 90-degree out-of-phase condition, by the same amount that the voltage on the cathode of V402 is greater.

(*6*) *Error Signal 120° Out-of-phase with Reference Voltage.* As shown in figure 195 (D), when the error signal is 120 degrees out-of-phase with the reference voltage, the cathode curves of V401 and V402 follow grids G1 and G3 for the first 180 degrees of reference voltage.

The cathode voltage of V402 reaches its minimum at 150 degrees while the cathode voltage of V401 reaches its maximum at 150 degrees. At 180 degrees the right-hand sections of V401 and V402 become operative, the cathode voltage of V401 falls abruptly because G2 is negative, and the cathode voltage of V402 rises abruptly because G4 is positive. The cathode voltage curves follow the curves of G2 and G4 to the end of the cycle. The result is that the average voltage on the cathode of V402 is less than the 90-degree out-of-phase condition, and the average value of voltage on the cathode of V402 is greater than the 90-degree out-of-phase condition. This results in an output control voltage which is opposite in polarity but equal in magnitude to the output of the 60-degree out-of-phase condition.

(*7*) *Summary.* Summing up all these conditions, it is shown that, for a pure error voltage 90 degrees out-of-phase with the azimuth reference voltage, no voltage differential exists between the cathodes of V401 and V402. Where the error signal is in phase with the reference voltage or out-of-phase by any amount except 90 degrees, a voltage differential is created between the cathodes and the direction of this differential depends on the amount of phase difference. These differential voltages in figure 195 have been shown to be developed by comparison of the phase difference of an azimuth error signal with the azimuth reference voltage. A similar circuit composed of V458, V452, and V451 serves to develop similar differential voltages when errors exist in elevation. The functioning of these circuits is identical, except that in the elevation circuits, the elevation reference voltage is 90 degrees out-of-phase with the azimuth reference voltage. When there is a pointing error in elevation and no pointing error in azimuth, the azimuth commutator circuit will not function because the error voltage (in phase with the elevation reference voltage) is 90 degrees out-of-phase with the azimuth reference voltage, and as shown in figure 195 (B), an error signal 90 degrees out-of-phase with the azimuth reference voltage will not cause a voltage differential between the cathodes of V401 and V402. Thus, the azimuth commutator circuit will not respond to a pointing error in elevation and likewise the elevation commutator circuit will not respond to a pointing error in azimuth.

(*8*) *General Error Signal in Automatic Tracking.* By general error signal, is meant the error signal produced when the antenna is off target in both azimuth and elevation.

(*a*) While figure 195 shows the results of phase relations between an error voltage and one reference voltage, figure 196 shows the conditions in which the same error voltage is compared to the azimuth and the elevation reference voltage. In figure 196 (A) the error voltage is in phase with the azimuth reference voltage so that a differential in cathode voltages is produced which will position the antenna in azimuth. In figure 196 (B) this same error voltage is 90 degrees out-of-phase with the elevation reference voltage because the azimuth reference voltage and the elevation reference voltage are always 90 degrees out-of-phase. In figure 196 (B) no differential in cathode voltages is produced and the antenna will not move in elevation. Thus it is seen that figure 196 represents a condition in which the antenna is on target in elevation but there is an azimuth pointing error.

(*b*) As another example, consider an error signal which is 30 degrees out-of-phase with the azimuth reference voltage and 60 degrees out-of-phase with the elevation reference voltage. Figure 197 represents such a condition. Note that this condition would bring about a 4-volt unbalance in azimuth and 2-volt unbalance in elevation. Thus, both the azimuth and elevation drive motors would rotate so as to bring the antenna into the on-target position and eliminate the error voltage.

b. D-c Amplifiers.

(*1*) A simplified schematic diagram of the azimuth d-c amplifiers is shown in figure 198. The elevation d-c amplifier circuits are identical to the azimuth circuits shown here. The average voltages of the commutator cathodes are impressed upon the control grids of the d-c amplifiers V403 and V404 through the filter circuits consisting of L401, R420, and C401; L402, R421, and C402; and the grid resistors R407 and R409. The purpose of the d-c amplifiers is to control the field currents of the servo motor-generators. The plate of each d-c amplifier is connected to the 300-volt supply through a field winding of a motor generator and as long as the cathode potentials of the commutator tubes are equal the currents flowing through the field windings of the

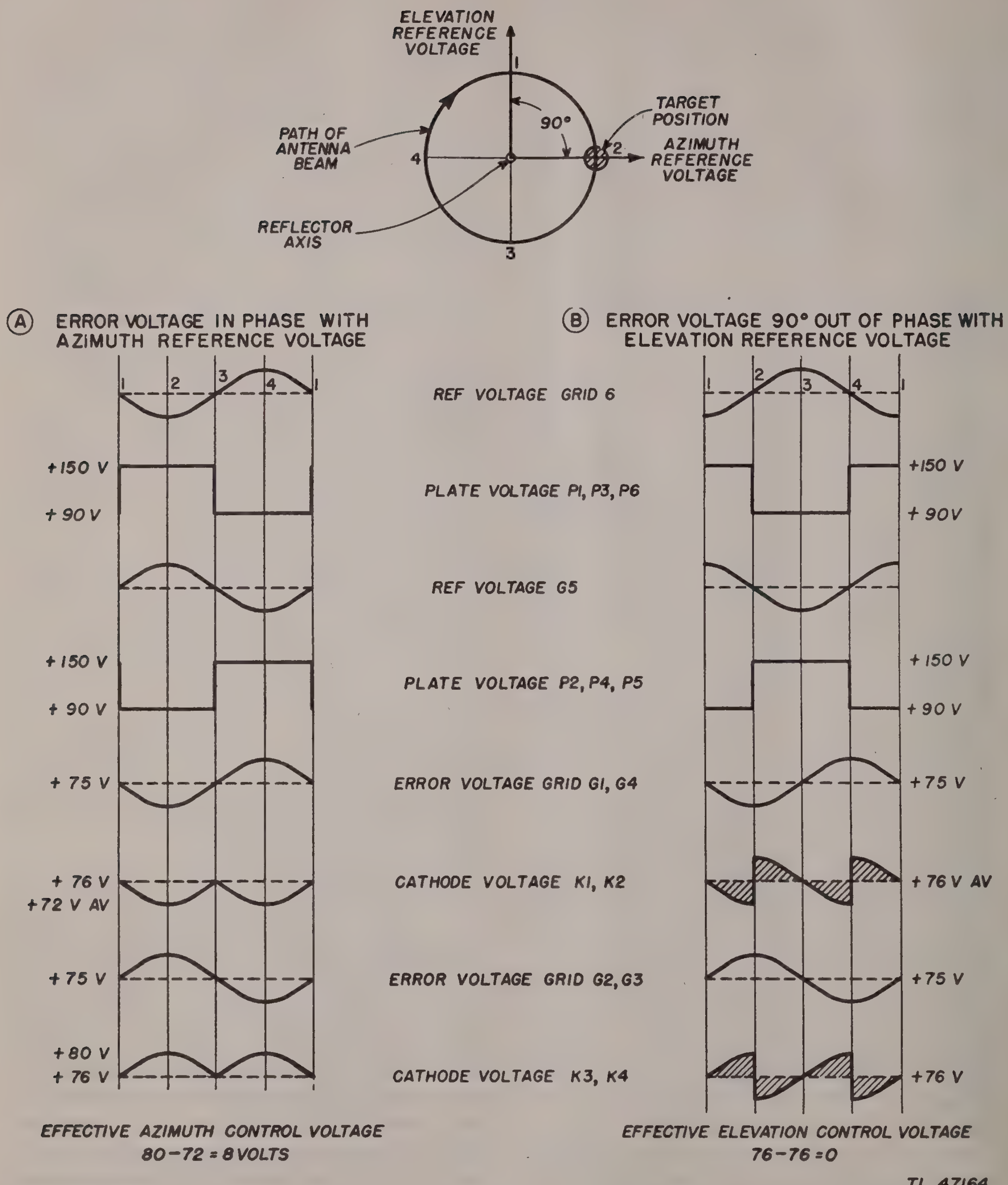

Figure 196. General error signal 0° and 90° out-of-phase with reference voltages.

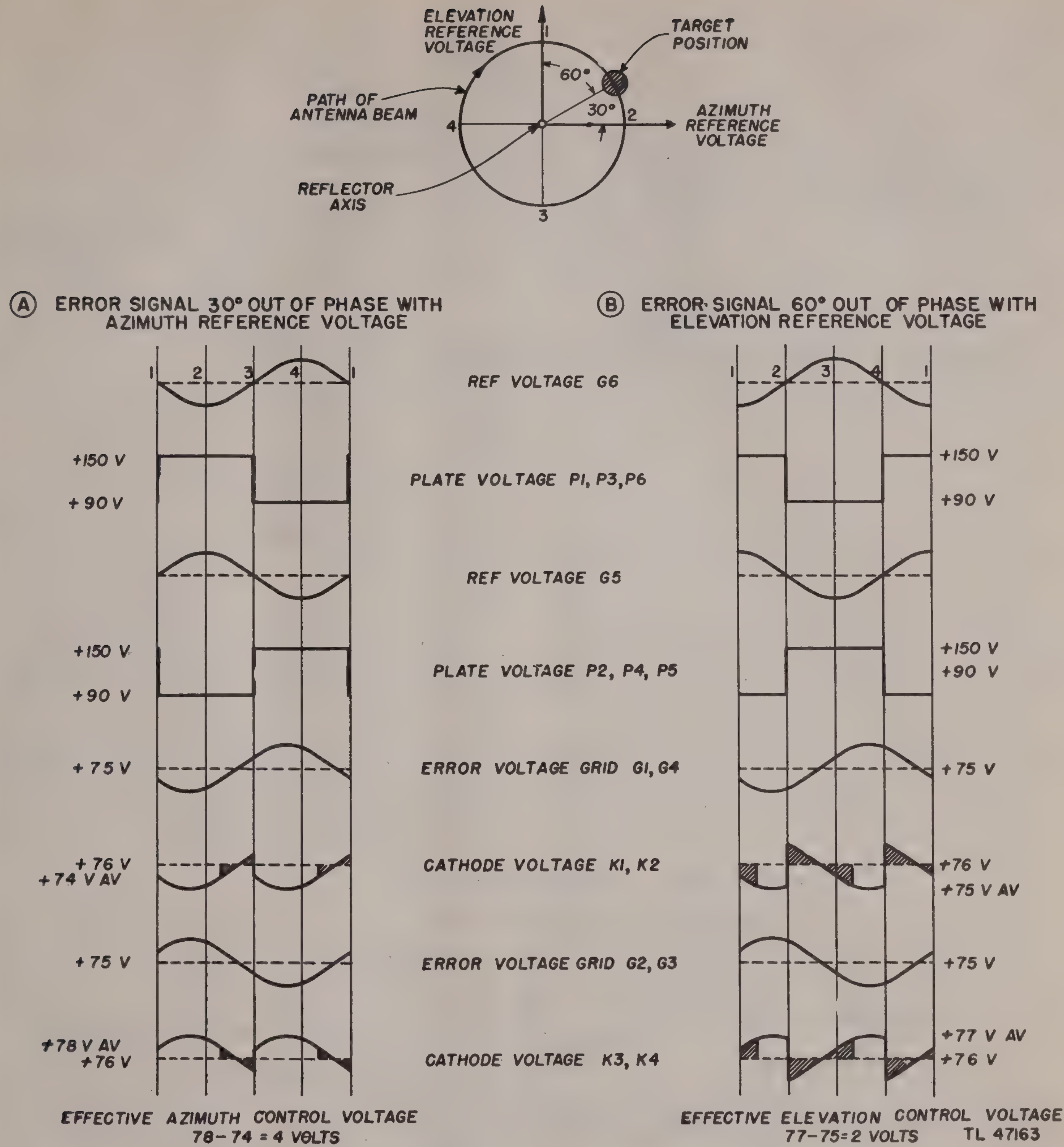

Figure 197. General error signal 30° and 60° out-of-phase with reference voltages.

motor generator are equal. These two fields are connected so that the magnetic flux produced by the two windings is opposing and hence only an unequal current flow through the fields will produce an output of the motor generator. Therefore, if the voltage at the cathodes of the commutator tubes is proportional to the magnitude of the error voltage, a proportional output is obtained from the motor generator. The currents of the d-c amplifiers are equal when there is no error signal and no unbalance in the output of the commutators. For this condition the motor generator fields are balanced and the antenna will not move. If there is an error signal, the output of the commutators is unbalanced and since the unbalance is applied directly to the grids of the d-c amplifiers, it unbalances the fields of the motor generator, and produces motor generator output. The plate current of the d-c amplifiers is the current in the motor generator

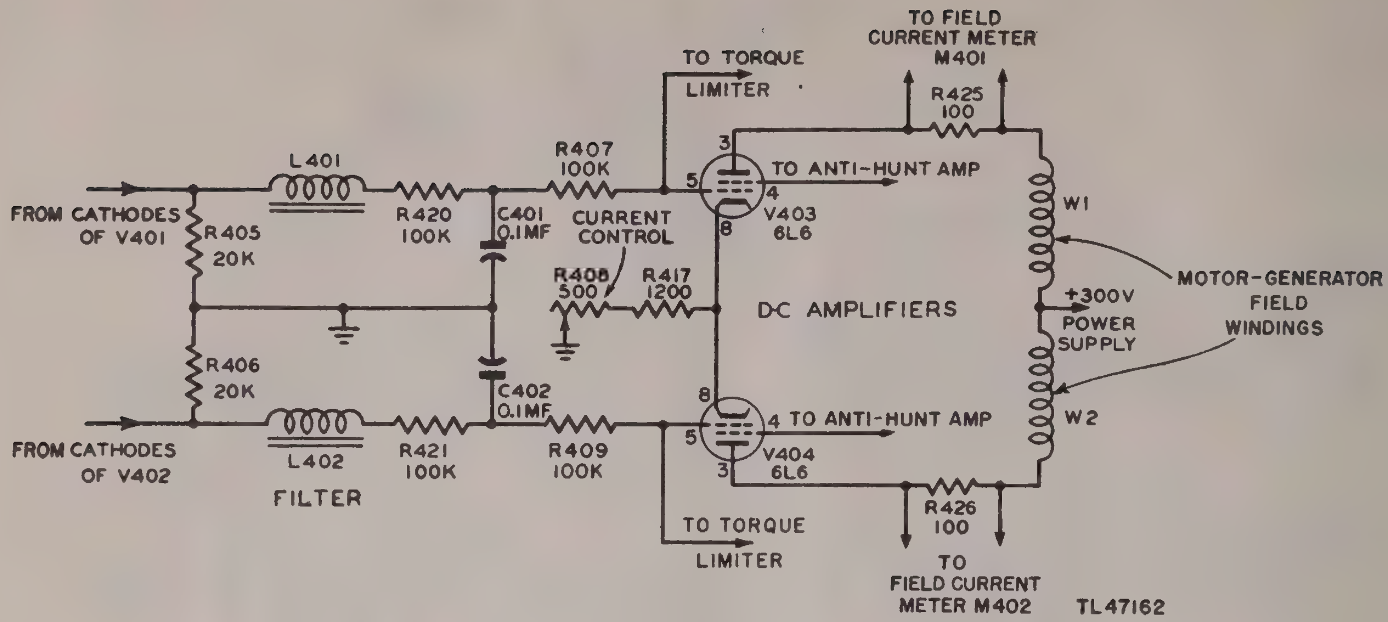

Figure 198. D-c. amplifier, simplified schematic diagram.

fields (since the fields are the plate load for the amplifiers). As shown in figure 213, the FIELD CURRENT meters M401 and M402 are so connected that they may read the two field currents of either the azimuth or elevation motor generator. CURRENT CONTROL potentiometers R408 and R458 adjust the field currents to the normal balanced value of 25 milliamperes.

(2) Besides their major function, the d-c amplifiers are involved in two other functions: torque limiting and anti-hunt control. The tube elements which are associated with these functions are shown in figure 198. Both torque limiting and anti-hunt control involve negative feedback, which is used to modify the flow of current through the d-c amplifiers.

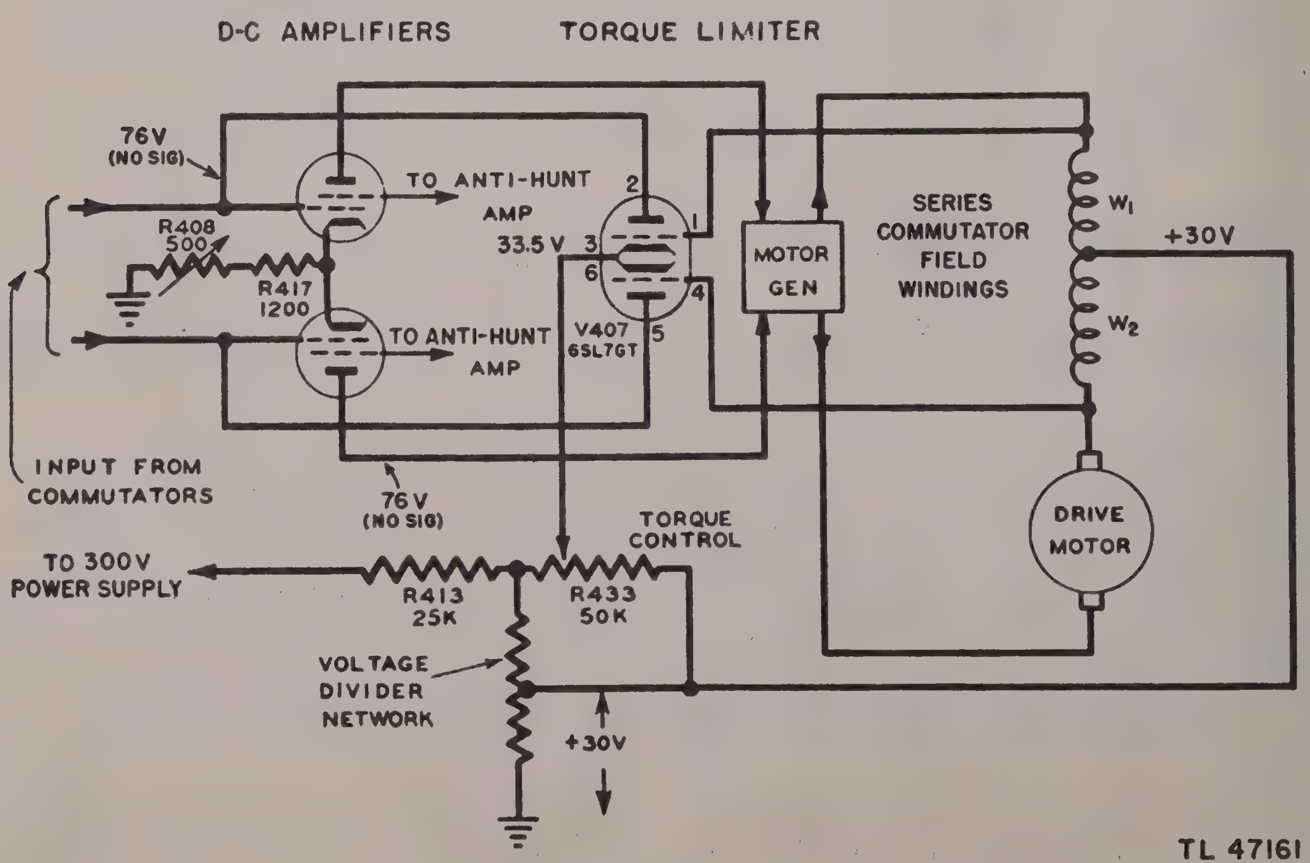

Figure 199. Torque limiting circuit, simplified schematic diagram.

c. Torque-limiting Circuit.

(*1*) A schematic diagram of the azimuth torque-limiting circuit is shown in figure 199. The elevation circuit is identical to the azimuth circuit shown here. The torque-limiting circuit does not operate until a d-c amplifier begins to send excessive current into the motor generator field winding. Then the torque-limiting circuit operates to reduce the control grid voltage of that d-c amplifier. This circuit plays an important part in manual and remote operation. If the control selsyn is turned at a rapid rate to position the antenna, the torque-limiting circuit impresses large voltages on the d-c amplifier grids in such a direction as to limit the torque to a safe value.

(*2*) The cathode voltage of the torque-limiting tube V407 is obtained through a voltage divider from the 300-volt supply and is approximately 33.5 volts. The grid voltages are obtained from the ends of the armature winding of the drive motor in the pedestal. The center tap of this winding is held at a potential of 30 volts, obtained from the voltage divider which supplies the cathode voltage. With no current in the armature of the drive motor, the grids of the d-c amplifiers are also at 30 volts. Since the plates of V407 are connected to the control grids of the d-c amplifiers, the plate potentials are approximately 76 volts. These voltage values keep V407 well below cut-off. However, if the control grids of the d-c amplifiers have a large signal applied, the motor generator supplies a large current to the armature of the drive motor. This current flows through the armature in a direction such as to make the end of winding W_1 positive with respect to the 30-volt potential of the center tap, and thereby raise the voltage applied to grid 1 of V407. When grid 1 reaches a certain potential, the top half of V407 conducts and drops the grid voltage of the d-c amplifier. This reduces the plate current of the d-c amplifier and, consequently, the torque applied to the drive motor. For a current in the opposite direction through the windings, the lower half of V407 conducts dropping the grid voltage of the other d-c amplifier, and limiting the torque applied to the drive motor.

d. Anti-hunt Circuit.

(*1*) The drive motor acts to turn the antenna to the position chosen by the operator or to the position of zero error signal. When this position is reached, the inertia of the system prevents the motor from stopping suddenly, and the antenna swings past the desired point. Once the antenna is past the desired point, an error signal is produced in the opposite direction which makes the antenna swing back toward, and again past, the desired point. Although it might appear that this oscillation or hunting would die out quickly, this is not always true. The characteristics of the antenna positioning system are such that often this oscillation increases rather than decreases, and violent hunting takes place.

(*2*) A simplified schematic diagram of the azimuth anti-hunt circuit is shown in figure 200. The elevation anti-hunt circuit is identical to the azimuth circuit shown here. As the antenna hunts, the current through the drive motor armature varies with the frequency at which the hunting takes place. The anti-hunt circuit uses this varying current to set up a varying voltage which acts to damp out these oscillations. Such a process is usually given the term negative feedback, and for this reason, the varying voltage from the anti-hunt circuit is called the feedback voltage.

(*3*) The feedback voltage is fed to the screen grid of the d-c amplifiers V403 and V404. The d-c amplifiers supply the current to the field of the motor generator, which in turn supplies the armature current of the drive motor. Consequently, a voltage variation at the screen grid of the d-c amplifiers brings about a current variation in the armature of the drive motor. But the voltage variation on the screen grids is itself brought about by the variation of current in the armature. Thus the armature current controls itself, because the connections are so made that any change in the armature current opposes itself. The amount of opposition can be set by the AH GAIN control on the front panel of the azimuth and elevation tracking unit.

(*4*) The anti-hunt circuit (fig. 200) is connected between the drive motor armature and the screen grid of the d-c amplifier. The circuit consists of the resistance divider R422 and R434 across the armature windings of the drive motor, a filter across the output of the resistance divider, another divider R424 across the output of the amplifier filter, and the anti-hunt tube V405. The plates of V405 and the screen grids of the d-c amplifiers are fed through the same dropping resistors R410 and R411, so that an increase in current of V405 results in a lowering of voltage on the screen grid of the d-c amplifiers. An

oscillating current through the armature of the drive motor produces a varying voltage across the input to the filter. The filter cuts off variations, which occur at less than one per second, so that the filter action is restricted to oscillatory motion and the circuit does not offer negative feedback to rapid movement of the antenna in one direction. One end of potentiometer R424 is maintained at a steady potential, and a voltage through the filter produces a varying voltage in R424 which is added to its fixed voltage and applied to V405. The peak magnitude of this voltage applied to the anti-hunt tube V405 increases as the arm of potentiometer R424 is moved to the right. Potentiometer R424 is the AH GAIN control mounted on the front panel of the azimuth and elevation tracking unit. The voltage output of R424 is applied to grid 1 of V405, and results in a voltage output on plate 2 of V405 which is applied to the screen grid of V403.

(*5*) In figure 200 plate 5 of the anti-hunt amplifier V405 is connected to the screen grid of V404. This utilizes the push-pull voltages produced at the plates of V405 as a result of the coupling through the common cathode resistor R419. Because of this common cathode coupling, equal and opposite changes in the voltages at the plates of V405 take place when an anti-hunt signal is applied to grid 1 of V405. Grid 4 of V405 is used to adjust the bias of one section of V405 so that, in the absence of an anti-hunt signal, the plate currents of the two sections of V405 are approximately equal.

(*6*) Rapid movement of the antenna in one direction requires extensive driving power, which can be produced only by considerable unbalance in the amplifier V403 and V404. This unbalance in turn requires appreciable error signal. The system thus has an inherent velocity error; i.e., the antenna must lag behind when following a fast-moving target or when on PPI

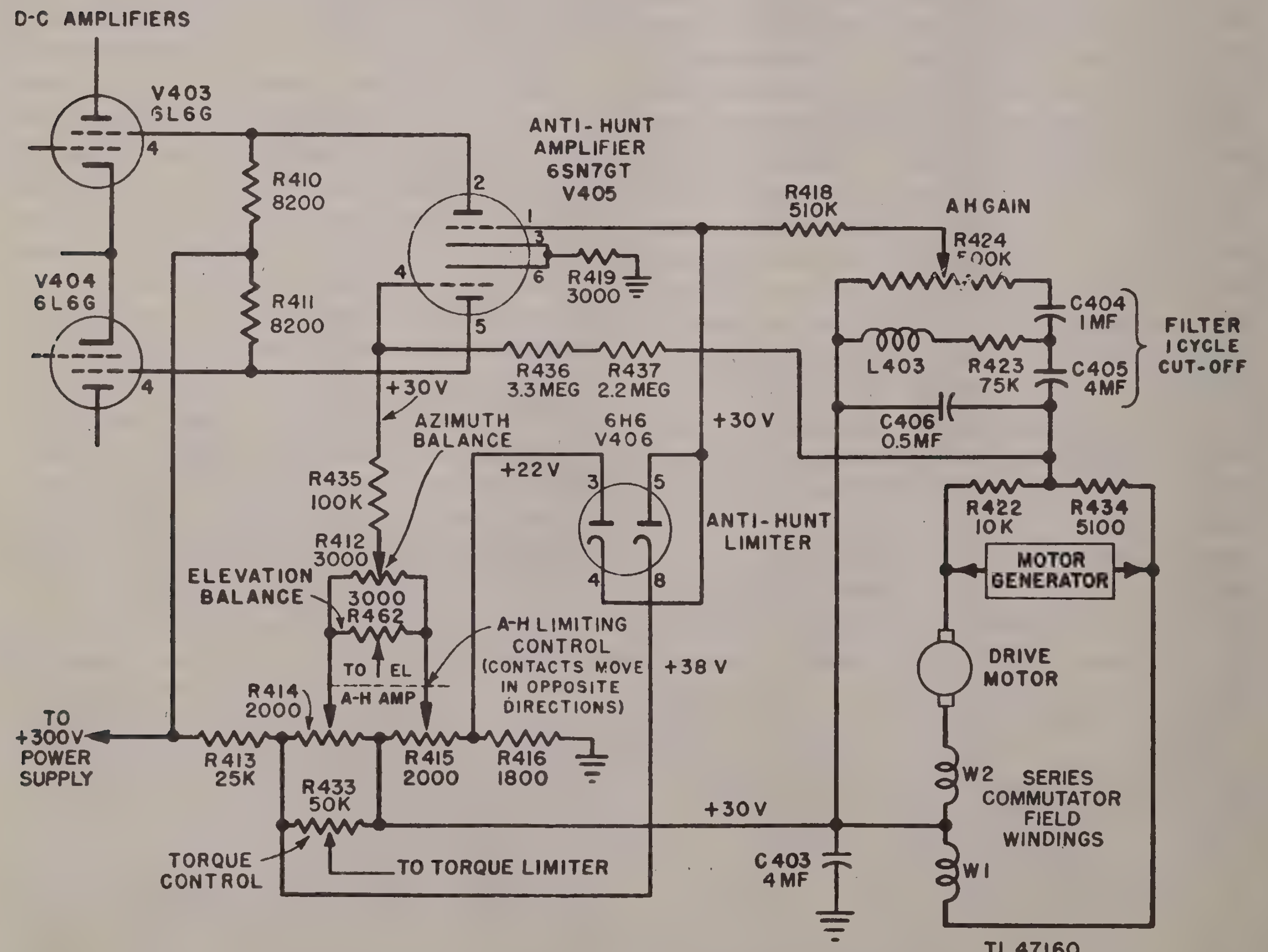

Figure 200. Anti-hunt circuit, simplified schematic diagram.

SCAN, in order that sufficient error signal voltage is sustained to yield required driving power. To reduce this velocity error to the vanishing point, a small amount of regenerative feedback is used. Resistors R436 and R437, totalling 6 megohms, carry this regenerative feedback signal from the input of the anti-hunt filter to grid 4 of V405 (fig. 200). This feedback signal is taken from the input of the filter to obtain d-c response when the antenna is moving in one direction. The value of feedback used is so small that negligible effect is produced on the degenerative anti-hunt feedback. Resistor R435 isolates the regenerative feedback signal from the low resistance BALANCE and AH LIMITING controls.

e. Anti-hunt Limiter. The function of the anti-hunt limiter is to prevent the antenna from moving through and off the target when switching from manual to automatic tracking. Without anti-hunt limiting, the anti-hunt signal might overpower the error signal and cause the antenna to move off target and the target to be lost. Anti-hunt limiting is accomplished by connecting the double diode V406 to grid 1 of the anti-hunt amplifier V405 (fig. 200) which receives the feedback signal. The right half of V406 conducts on large positive voltages and the left half conducts on large negative voltages. The approximate voltages on V406 with no anti-hunt signal are as follows: Plate 3, +22 volts; cathode 8, +38 volts; plate 5 and cathode 4, +30 volts. The reference level of the anti-hunt voltage is also 30 volts. These voltages are all varied by the setting of the AH LIMITING control. As soon as the peak of the anti-hunt feedback becomes greater than 8 volts (either positive or negative) V406 conducts and prevents the feedback voltage from rising to a greater value.

166. ELEVATION LIMIT SWITCHES.

Elevation limit switches are connected into the elevation section of the antenna positioning system because the antenna elevating mechanism is designed to operate only from slightly below horizontal to vertical. The elevation limit switches prevent excessive driving forces that would damage the mechanism when it reaches the limits of elevation. Figure 201 is a schematic diagram showing the elevation limit switches. There are two switches, one for maximum height and one for minimum height. Since the operations are similar, only the action of S2055 will be explained in detail. CR1901 and CR1902 are

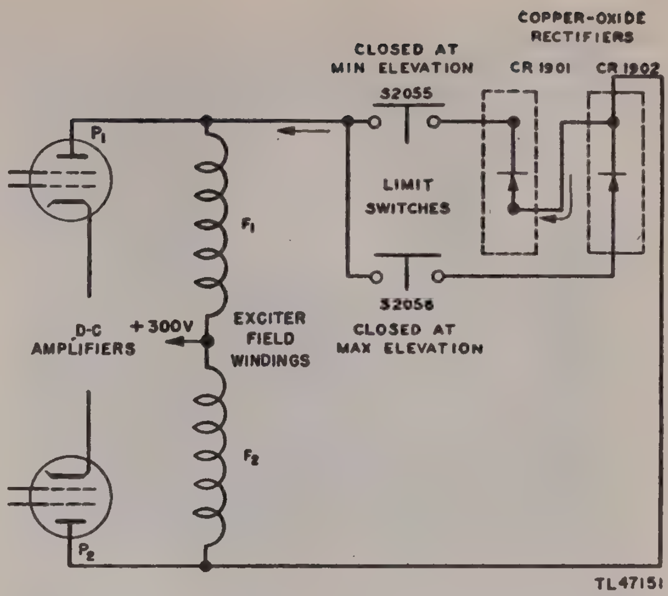

Figure 201. Elevation limit switches, simplified schematic diagram.

copper-oxide rectifiers which pass current through them in one direction only. When the antenna is moving toward the minimum elevation, the voltage at P1 is lower than the voltage at P2 due to the action of the d-c amplifiers. When switch S2055 closes at minimum elevation, the fields are shorted through CR1901 as indicated by the arrows, and the antenna will stop moving. However, the antenna can be tilted upward, since the voltage at P1 will be greater than the voltage at P2, and current will not flow in the opposite direction (even though switch S2055 is closed) because of the action of the copper-oxide rectifier. In like manner S2056 closes when the antenna reaches a certain maximum elevation, shorting across the field windings, and preventing any further movement of the antenna.

167. CONTROL SWITCH.

The indicator-control panel (fig. 202) contains CONTROL SWITCH S1751 (which selects the method of operation), COAST button S1752, SAFETY SWITCH S1753, DIRECTOR SIGNAL switch S1754, and relay K1751. These switches and this relay control the positioning at the antenna. Fuses F1904, F1905, and F1906 of the switch and data panel pass 115-volt a-c power to jack J1203 of the antenna position indicator unit, which is then distributed to the relay circuits and to the power supply of the automatic tracking unit through the cables connecting the various components of the antenna positioning system. Figure 203 shows the circuits affected by the CONTROL SWITCH on the indicator-control panel and shows the power distribution from the fuses mentioned.

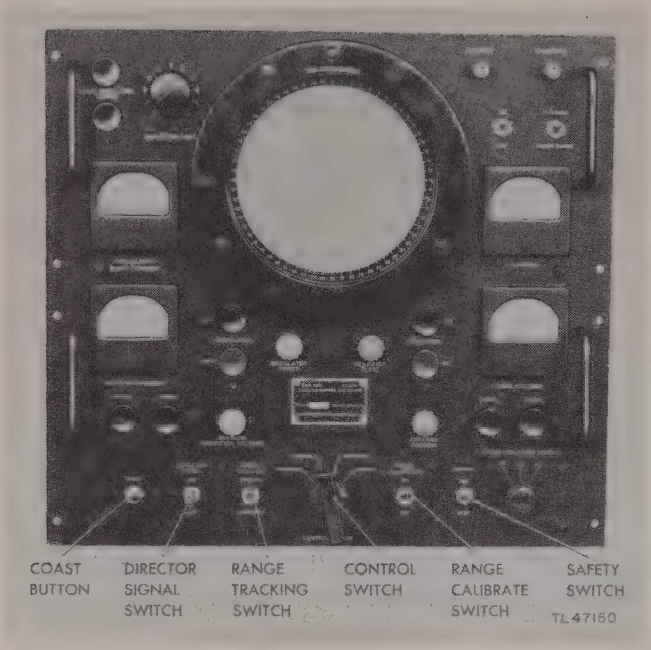

Figure 202. Indicator-control panel, front view.

a. SAFETY switch S1753 energizes relay K502 in the automatic tracking unit if all of the interlock circuits of the pedestal are closed.

b. Relay K701 in the automatic gain control (AGC) circuit of the receiver is energized if relay K1751 is de-energized and the AGC switch of the receiver is closed (OFF). Relay K1751 is energized only when the CONTROL SWITCH S1751 is in the AUTOMATIC position.

c. Scan motor B1302 (to produce the PPI scanning) is energized through CONTROL SWITCH S1751 when it is in the PPI SCAN position if SAFETY switch S1753 is closed.

d. The manual-automatic relays K401 and K402 of the azimuth and elevation tracking unit and the magnetic brakes E1301 and E1351 of the antenna position control unit are energized when CONTROL SWITCH S1751 is in the AUTOMATIC position.

e. The local-remote relays K1201 and K1202 of the antenna position indicator unit are energized when CONTROL SWITCH S1751 is in the REMOTE position.

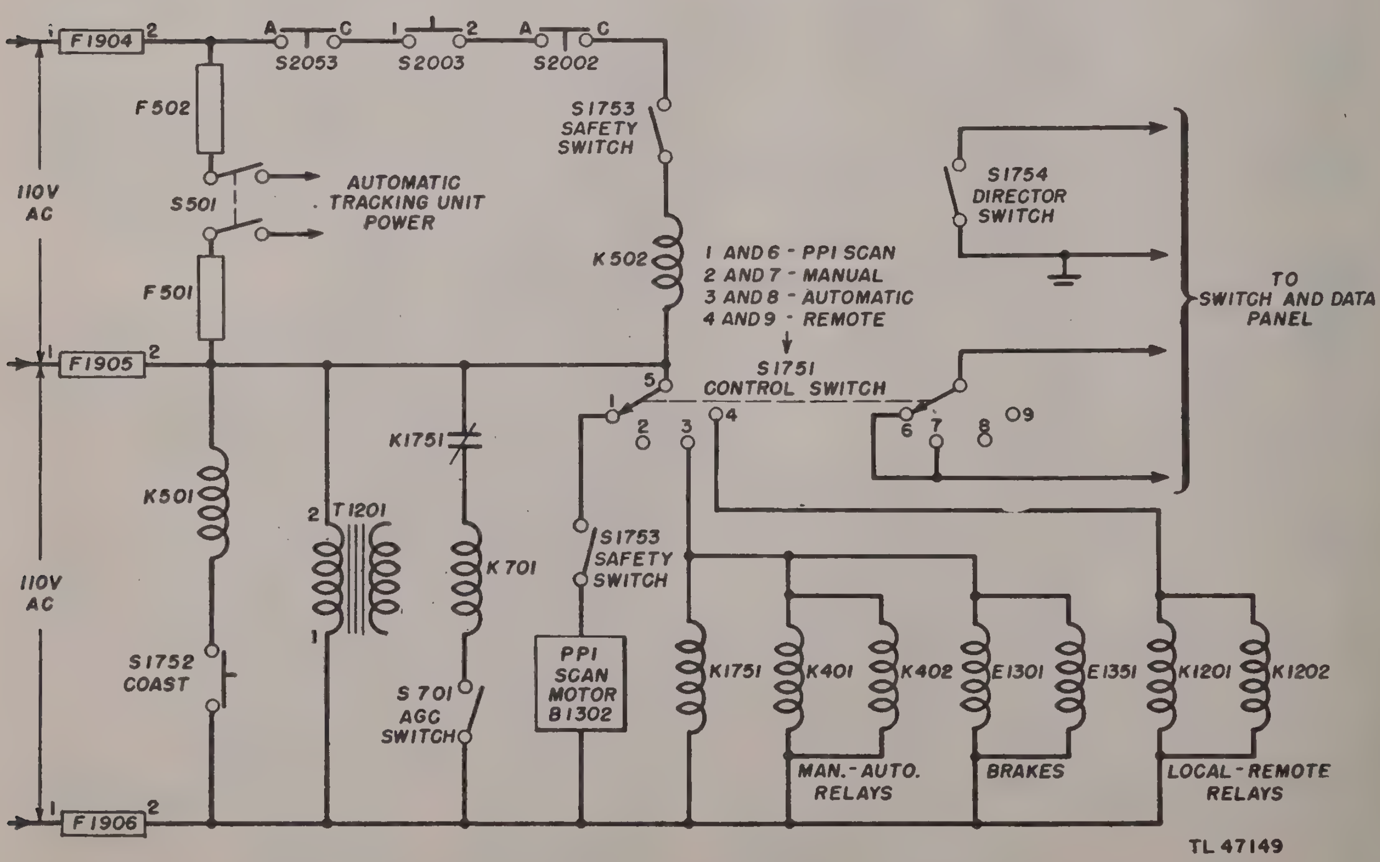

Figure 203. Indicator-control panel, simplified schematic diagram.

SECTION IV

SERVO MOTOR-GENERATORS AND DRIVE MOTORS

168. SERVO MOTOR-GENERATORS.

a. As shown in figure 204, the servo motor-generator is essentially an exciter-generator set with the armatures of both the d-c exciter and the d-c generator being turned at constant speed by a three-phase motor. An exciter is simply a small generator. The current generated in the exciter armature is supplied to the field of the generator. Although the exciter and the generator are essentially the same, the output is taken from the generator alone, and for this reason they are given different names.

b. The difference of current between the two d-c amplifiers in the azimuth and elevation tracking unit is supplied to the field of the exciter. The armature of the exciter is turned continually by a motor, so that voltage is generated whenever there is a net field in the exciter. This generated voltage causes current to flow through the armature of the exciter and through the field of the generator (which is the exciter load). The construction of the generator is such that its field is much larger than the field of the exciter. Thus the generator functions as an amplifier.

c. The operation of the generator is the same as the operation of the exciter. The armature of the generator is turning continuously, the field is supplied by the exciter, and a voltage proportional to the generator field is produced. This voltage causes a current to flow through the generator armature and through the generator load (which is the armature of the drive motor). The output of the generator is much larger than the current in its field, so that the generator may be looked upon as another stage of amplification, and the servo motor-generator as a whole is sometimes termed a two-stage power amplifier. The over-all gain of the exciter and generator is such that a current differential of about 13 milliamperes through the field windings of the exciter produces a voltage of 250 volts at the output of the generator and about 2 amperes flow in the drive motor armature.

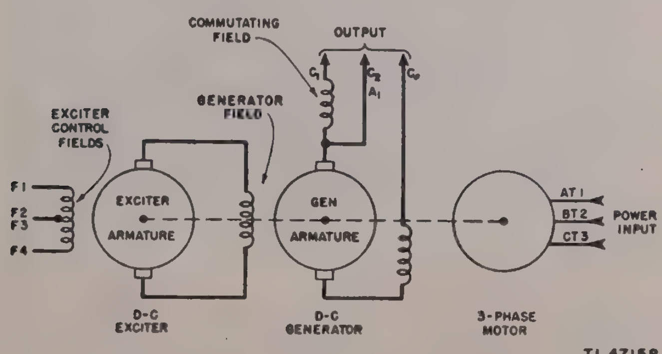

Figure 204. Servo motor-generator, schematic diagram

169. DRIVE MOTORS.

a. The drive motors of the pedestal which produce the mechanical motion to actually turn the pedestal are conventional 250-volt d-c motors. These motors, however, have their field supplied with a constant voltage from the field power supply so that the output of the motor generators (which is varying in voltage and polarity) produces rotation in the desired direction and at the desired speed.

b. The ability to run in either direction and at variable speeds is a characteristic of direct-current motors.

(*1*) To reverse the direction of a direct-current motor, it is necessary to reverse the relative polarity of the field and armature. This is accomplished by using the constant field excitation and having an armature voltage which may be of either polarity. This armature voltage is supplied by the motor generator. The polarity of the armature voltage is controlled by the action of the circuits in the azimuth and elevation tracking unit. These circuits determine which of the two exciter control fields of the motor generator carries the greatest current and so determine the polarity of the drive motor armature voltage.

(*2*) To vary the speed of a direct-current motor the armature voltage or the field voltage must be varied. In this case the amount of difference in the exciter control field currents controls the output of the motor generator, and

the variable output of the motor generator varies the drive motor armature voltage, thus varying the speed of the drive motor.

170. FIELD POWER SUPPLY.

The purpose of the field power supply (Rectifier RA-71-A) is to supply the fixed field of the drive motors in the pedestal. The input to the field power supply is the 115-volt a-c line voltage and its output is a 300-volts d-c voltage. Top views of this component are shown in figure 76 in connection with the remote video amplifier, which is mounted on the same chassis, and the schematic diagram is shown in figure 205. The input a-c power is through fuses F1153 and F1154 to transformers T1152 and T1153. Since a switch is not included in the field power supply, it is energized when the MAIN LINE SWITCH is thrown to the ON position. A simple full-wave rectifier circuit is used. Resistors R1157, R1158, and R1159 form a bleeder. No filter is used because the inductance of the motor fields is sufficient to smooth out the pulsating d-c produced by the rectifier.

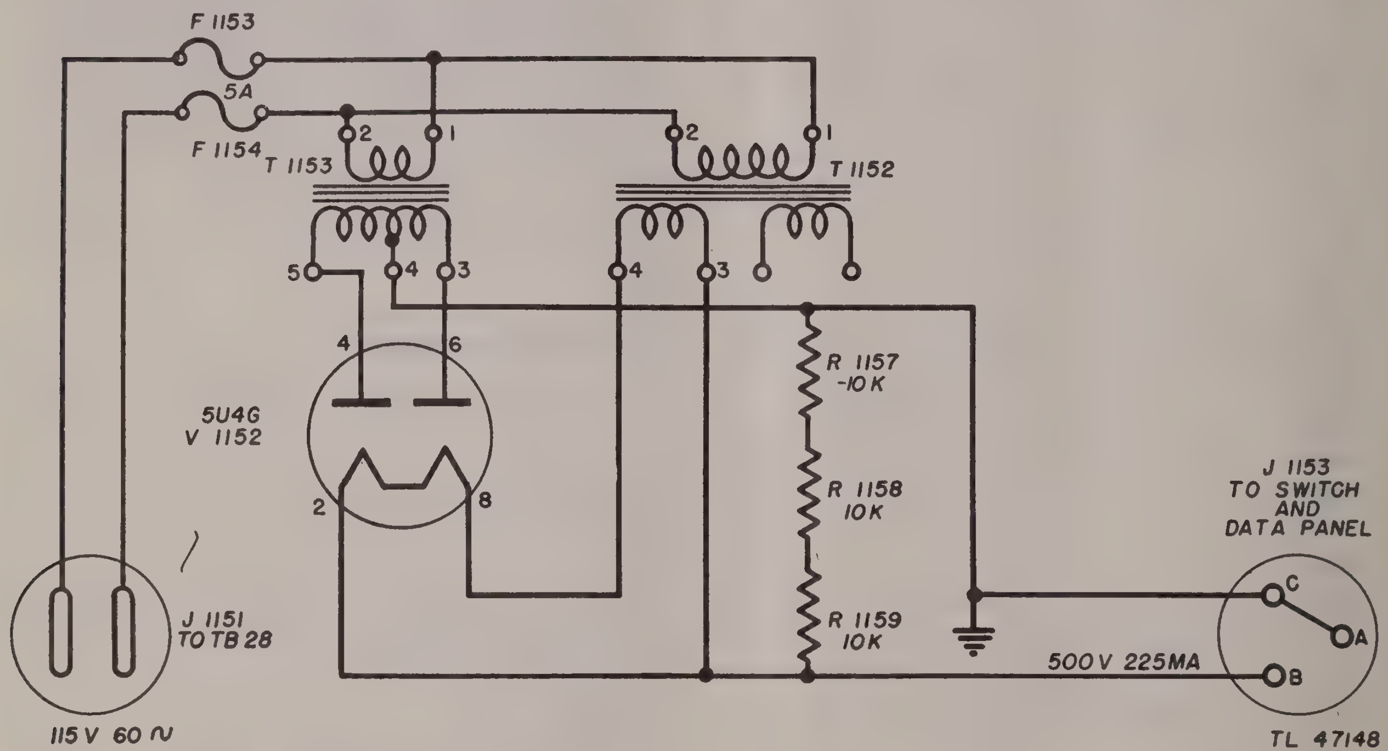

Figure 205. Field power supply, schematic diagram.

SECTION V

ANTENNA POSITION CONTROL UNIT

171. GENERAL.

The antenna is positioned manually by turning the handwheels of the antenna position control unit when the CONTROL SWITCH on the indicator-control panel is in the MANUAL position. As has been stated, this same type of control is really effected for the PPI SCAN and REMOTE positions of the CONTROL SWITCH, except that the operator of the SCR-784 is replaced by a scanning motor or by the operators of the gun director. Thus, the following discussion applies to all methods of antenna positioning except AUTOMATIC. A front view of the antenna position control unit is shown in figure 206, a top view is shown in figure 207, and a complete schematic diagram is shown in figure 215.

172. OPERATION.

a. Manual positioning.

(*1*) *Selsyn Control System.* Manual antenna positioning is accomplished through the selsyn control system which supplies azimuth and elevation error signals to the azimuth and elevation tracking unit. The selsyn control system is shown in figure 208. When the selsyn transformer rotor is in the position shown in figure 208(B), the rotor has no voltage induced in it. In any other position except that shown in figure 208(B), the rotor has an induced voltage. This one position in which no voltage is induced is called the static position. With the rotor in the static position, the azimuth and elevation tracking unit receives no voltage from the selsyn, but with the rotor in any other position the azimuth and elevation tracking unit receives a voltage proportional to the departure of the rotor from the static position.

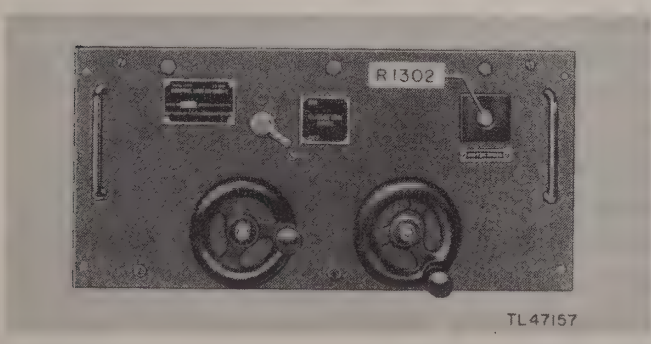

Figure 206. Antenna position control unit, front view

(*2*) *Operation of Selsyn Transformers.*

(*a*) A selsyn is a device used for the electrical transmission of an angular position. Essentially the selsyn has the form of a small two-pole alternator. The rotor is turned by a shaft mounted on ball bearings, and has a single coil of wire wound on an iron core constructed of thin sheets to minimize eddy currents. The ends of the coil are connected to slip rings and then to terminals R_1 and R_2 on the frame. The stator is usually fixed in position and may act as part of the frame. The stator also is constructed of thin iron sheets, and has uniformly spaced slots, into which are wound three separate coils. The coils are spaced 120 degrees apart around the stator and distributed in several pairs of slots. A corresponding end of each coil is connected to a common point and the other ends are connected to terminals S1, S2, and S3 on the frame.

(*b*) In both selsyns (fig. 208) the rotors are the inner moving elements, while the stators are the outside elements which are usually stationary. In the control selsyn in both figures 208(A) and 208(B) a 60-cycle voltage in the rotor sets up an alternating field in the stator windings in a direction opposite to the rotor field. Thus S1 of the control selsyn windings has no current flowing in it because it is at a right angle to the rotor, while S2 and S3 have currents because these windings have components in the direction of the rotor field. Since the stator of the control selsyns and the stator of the selsyn transformer are electrically connected, a current in the stator of the control selsyn produces a current in the stator of the selsyn transformer. Both rotor fields are at right angles to windings S1 of their respective selsyns. If the rotor of the selsyn transformer is at a right angle to the stator field of the selsyn transformer, then the rotor will have no

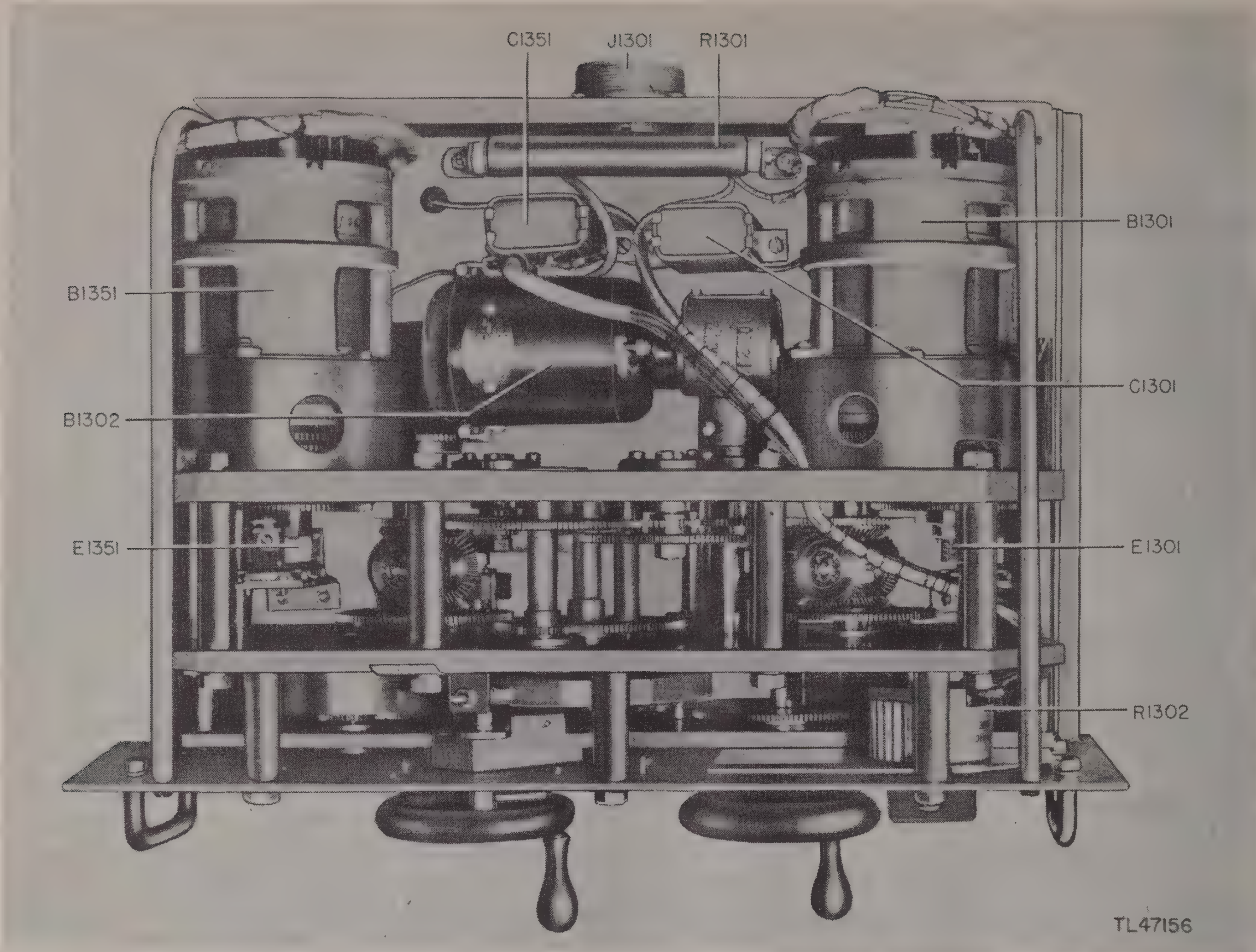

Figure 207. Antenna position control unit, top view.

voltage induced in it, and the static case shown in figure 208(B) is produced. If the selsyn transformer rotor is in any other position (fig. 208(A)) a voltage is induced in the rotor. When the handwheel is turned, the control selsyn rotor (mechanically connected to the handwheel) and the rotor field take on a new position. The field of the control selsyn stator rotates, and the stator field of the selsyn transformer follows the stator field of the control selsyn. This induces a voltage in the selsyn transformer rotor, and this voltage is used to control the drive motor and turn the antenna through an angle equal to that through which the handwheel has been turned. At this point the selsyn transformer rotor again takes up a position at right angles to the field of its stator and there is no longer any voltage induced in the rotor.

(3) *Operation of Selsyn Receivers.*

(*a*) A mechanical motion of the control selsyn rotor is transferred to a mechanical motion of the rotor of the receiving selsyn. The rotor fields must alternate in direction because the operation of the selsyn depends on the transformer action between rotor and stator. Since the rotor fields are alternating, they must always be in phase if the two selsyns are to keep in step. This is easily accomplished by connecting the rotor of the receiving selsyn to the same a-c supply source as the rotor of the control selsyn.

(*b*) The twist or torque on the receiving selsyn rotor shaft depends on the angular difference between the stator and rotor field directions. So long as the receiving selsyn rotor shaft is free to turn without any frictional drag or load, any slight movement of the control selsyn rotor (and thus the receiving selsyn stator field) develops sufficient torque to cause the receiving selsyn rotor to follow. A selsyn designed for a free turning rotor would probably overheat if the rotor were held fixed so that the

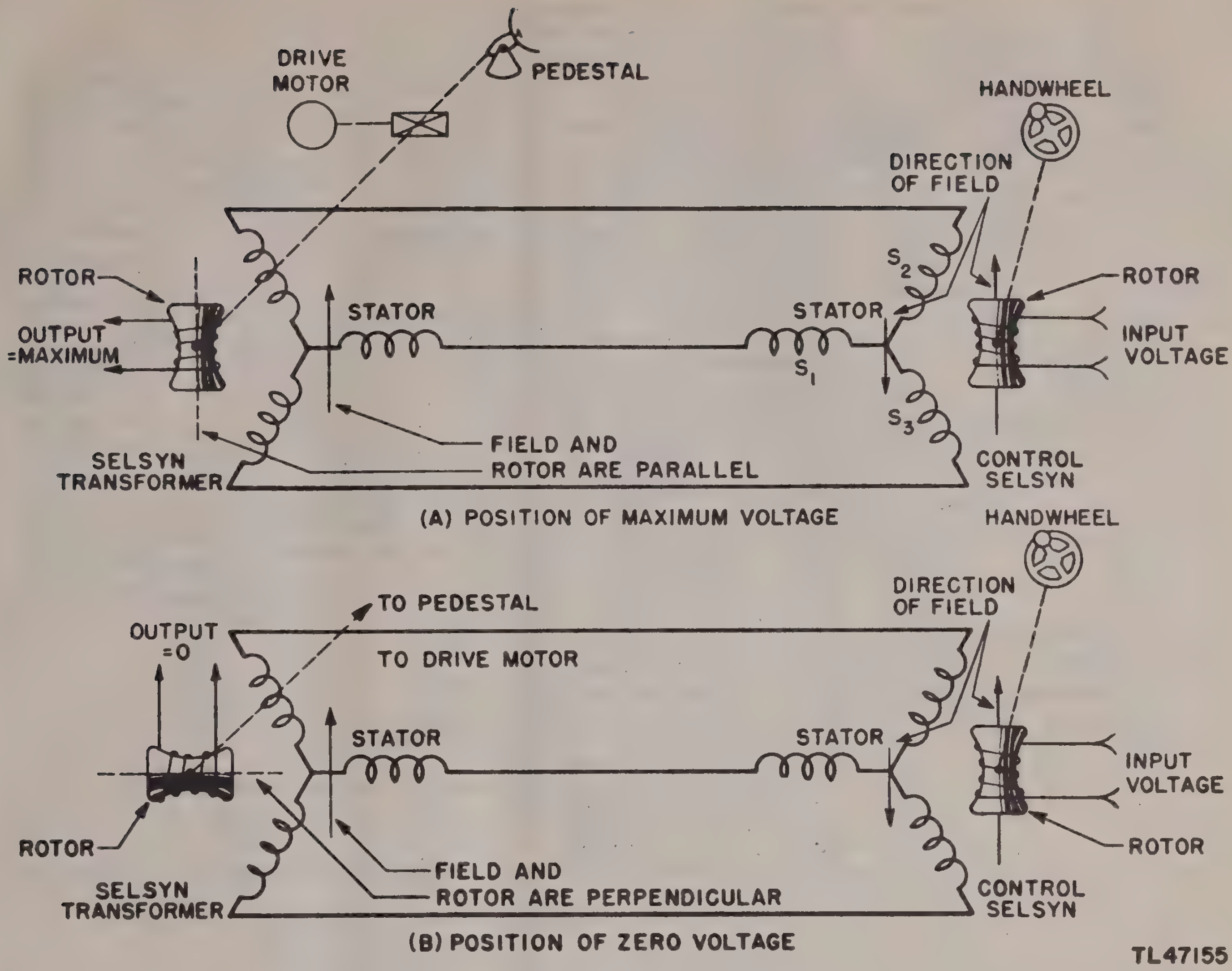

Figure 208. Selsyn control system.

angle between it and the stator field became greater than 20 degrees. The control selsyn is frequently called a selsyn generator and the receiving selsyn a selsyn motor. Electrically, the selsyn generator and the selsyn motor are identical. Physically they differ somewhat in that the motor has mounted on its rotor shaft an oscillation damper. This damper consists of a lead ring mounted within a friction plate on a sleeve which is secured to the rotor shaft. The lead ring has a large amount of inertia and can be rotated on the sleeve only with considerable difficulty. In case of any violent oscillation of the rotor, the lead ring cannot follow this motion because of its inertia and a large damping effect is produced on the oscillating rotor. It should be noted that a selsyn generator does not necessarily rotate continuously as do most electrical generators, but may merely change its position by a few degrees. Similarly a selsyn motor may not rotate continuously, but follows in step with any movement of the selsyn generator. Currents in the three wires connecting the selsyn stators have their maximums at the same time, but vary in magnitude according to the rotor position. Therefore, the a-c voltage and currents in selsyns are single phase.

(*4*) *Relays*. To complete the picture of the circuits for manual, PPI scan, and remote operation, figure 209 shows the connection through the automatic manual relays K401 and K402 to the squarer and commutator tubes. The inputs to the squarer grids are 115-volt 60-cycle sine waves obtained through transformer T1202 from the a-c line which supplies the rotors of the control selsyns with power. The commutator grids are fed with the outputs from the selsyn transformer rotors through transformer T401 for the azimuth channel and transformer T451 for the elevation channel. The outputs of the selsyn transformer rotors are either in phase or 180 degrees out-of-phase with the voltage obtained from the selsyn rotor bus. These selsyn transformer outputs are the azimuth and elevation error signal voltages. The azimuth error signal voltage is fed to the grids of the azimuth

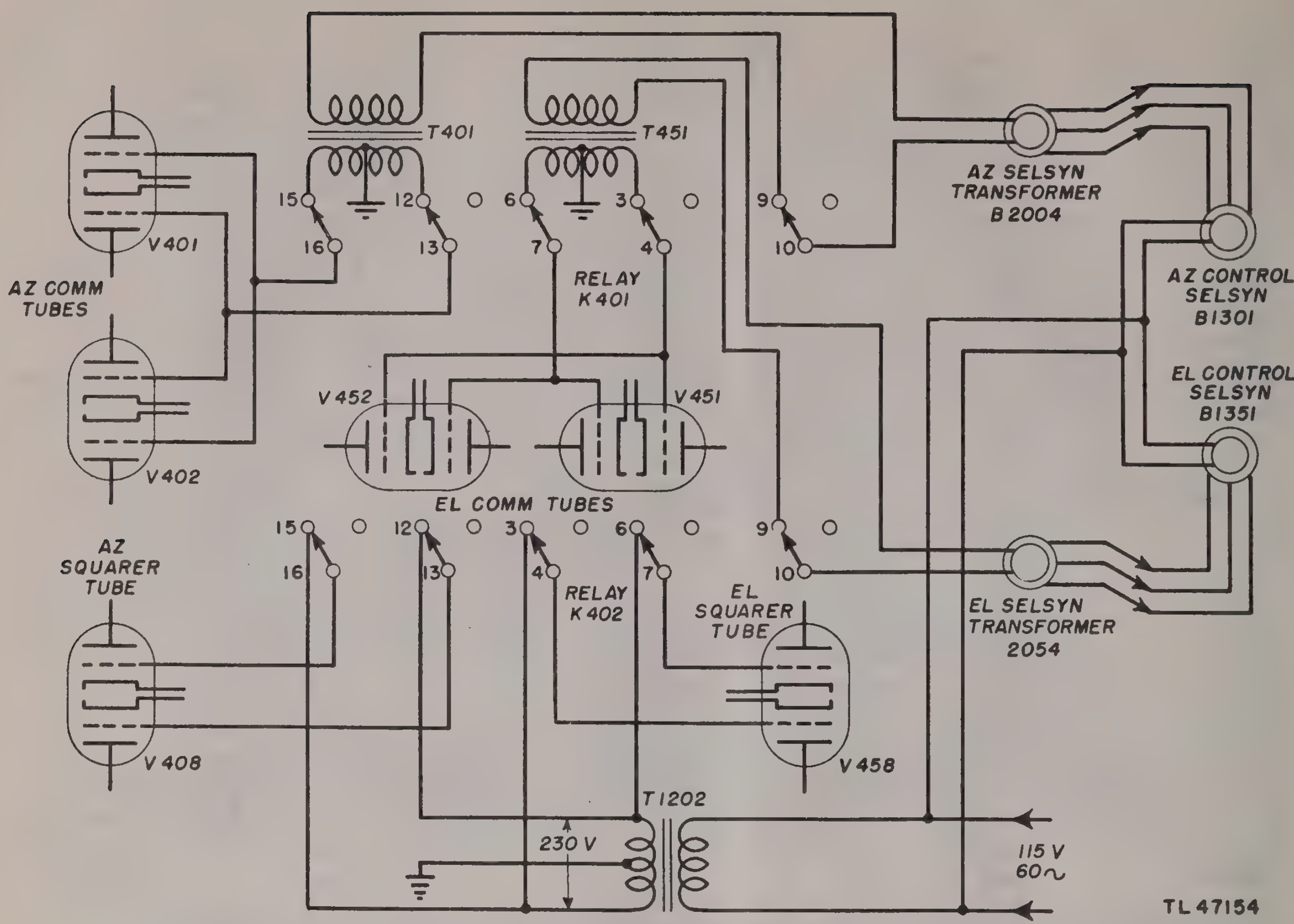

Figure 209. Connections to relays for manual positioning.

commutator tubes from the azimuth selsyn transformer B2004 through T401, and an elevation error signal voltage is fed to the grids of the elevation commutator tubes from the elevation selsyn transformer B2054 through T451.

b. Mechanical Features.

(*1*) The antenna position control unit contains the gearing mechanism necessary for manual and PPI-scan operation. Also included in this unit are the follow-up motors which are described in subparagraph **d** below. The actual mounting of the control selsyns in the antenna position control unit is such that both the stator and the rotor are geared to driving devices. The stator is rotated about a stationary rotor for manual and PPI-scan operation. This accomplishes the same result as turning the rotor. As shown in the gearing diagram (fig. 210), this rotation of the stator is effected through differential gears by either the handwheels or the scanning motor. The elevation scanning is accomplished with a cam and roller.

(*2*) The rotors of both control selsyns are moved by the follow-up motors. This movement affects the relative positions of the stator and rotor so that, when the set is automatically tracking a target, the control selsyns automatically follow the movement of the antenna. Magnetic brakes (E1301 and E1351 of figure 215) are used on the azimuth and elevation control selsyns. These brakes are energized to hold the rotors more definitely stationary when the control selsyns are being used to position the antenna.

c. Scanning Motor. The scanning motor B1302 (sometimes designated as the PPI scan motor) is a 115-volt a-c motor of the commutator type. The connections of its field and armature are shown on the schematic diagram (fig. 215). R1302 is an adjustment of the armature voltage to control the motor speed and is normally set to produce approximately 5 revolutions of the antenna in azimuth per minute.

d. Follow-up Motors.

(*1*) The follow-up motors B1303 and B1353 prevent violent slewing of the antenna when switching from automatic to manual or PPI-scan operation. In automatic operation the

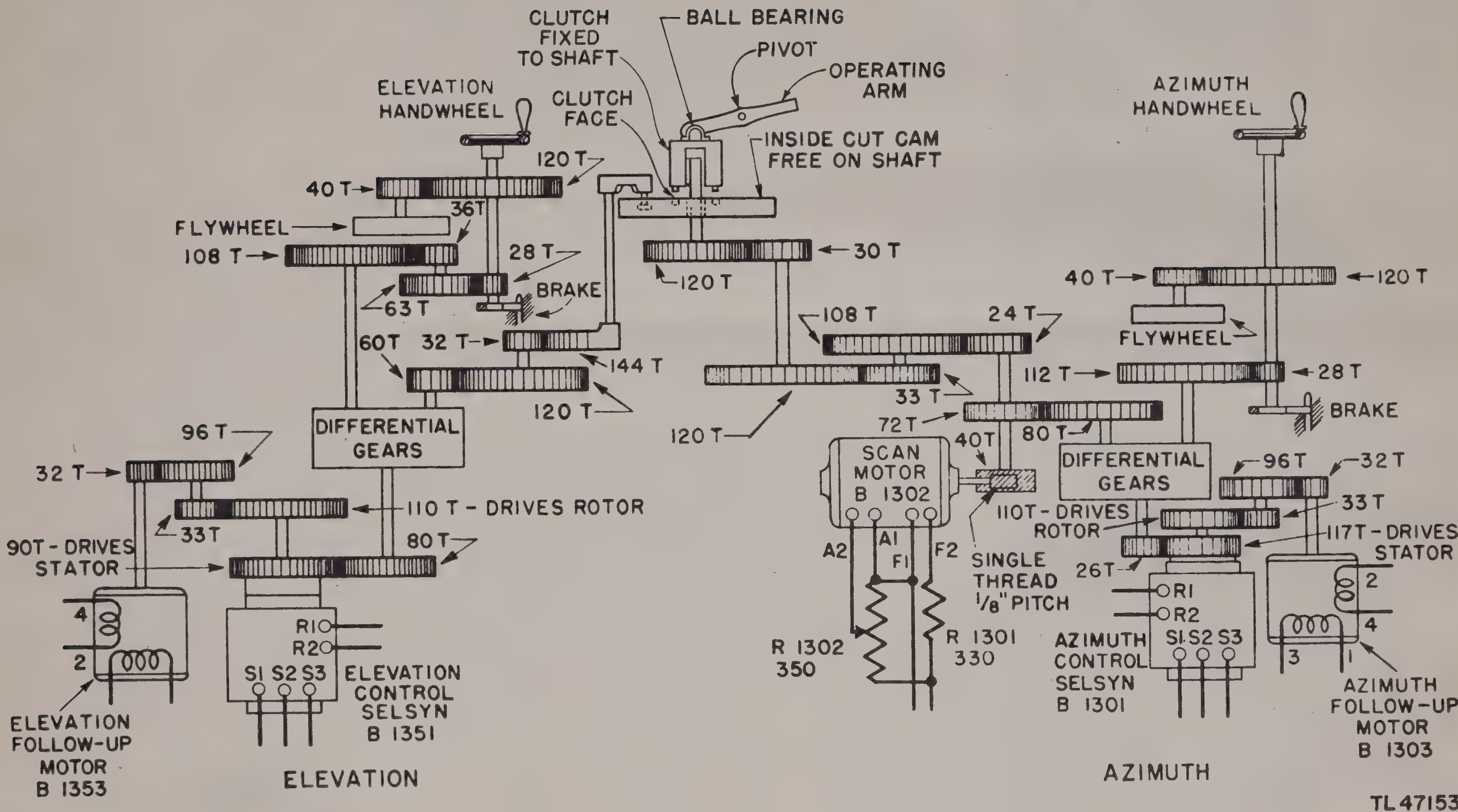

Figure 210. Antenna position control unit, gearing diagram.

control selsyns no longer control the positioning of the antenna, but if they were left to drift, large error signals would be produced in the selsyn transformer. Consequently, large forces would be applied to the antenna when switching from automatic to manual operation. The follow-up motors are provided to make the positions of the control selsyns correspond to the actual position of the antenna during automatic tracking.

(*2*) The follow-up motor (fig. 215) is a two-phase induction motor with two fields 90 degrees out-of-phase. Both fields must be present in order to cause the motor to move. In the follow-up motor, one of the fields is provided by the voltage from the selsyn excitation bus connected to a 60-cycle line voltage and is present at all times. The other field is obtained from the selsyn transformer. The voltage producing the other field is essentially an error signal which will be zero only when the control selsyn rotor is positioned correctly with respect to the antenna. When this error signal voltage is impressed on the follow-up motor, the motor runs. Since the follow-up motor is mechanically connected to the control selsyn, the control selsyn rotor is turned to the position which corresponds to the position of the antenna. When this position is reached, the follow-up motor no longer receives a voltage from the selsyn transformer and the motor stops running. Thus, slewing of the antenna is prevented when switching from automatic to manual operation.

SECTION VI

ANTENNA POSITION INDICATOR UNIT

173. ANTENNA POSITION INDICATOR UNIT.

a. Function. The function of the antenna position indicator unit is to indicate to the operator of Radio Set SCR-784 the direction which the antenna and the gun director telescopes are pointing. The operation of this unit in connection with the gun director is closely linked with the data transmission system and is discussed in chapter 8 of this manual. Front and rear views of this unit are shown in figures 6 and 336.

b. Indicator Dials. The local azimuth receiving selsyn B1201 is geared to the local azimuth index with a 1 to 1 ratio. The stator of B1201 is connected to the coarse azimuth transmitting selsyn in the pedestal. Consequently, the local azimuth index indicates the azimuth of the antenna. The local elevation receiving selsyn B1251 is geared to the local elevation index with a 1 to 1 ratio and the local elevation index indicates the elevation of the antenna.

c. Local-remote Relays. The operation of the local-remote relays K1201 and K1202 (fig. 214) is outlined in the following tabulation:

(*1*) The relays are de-energized for the PPI scan, manual, and automatic methods of operation, and when de-energized the following connections are made:

(*a*) The azimuth transmitting selsyn of the director is connected to the remote azimuth receiving selsyn B1202 by relay K1201.

(*b*) The azimuth control selsyn is connected to the azimuth selsyn transformer for antenna positioning by K1201.

(*c*) The elevation transmitting selsyn of the director is connected to the remote elevation receiving selsyn B1252 by K1202.

(*d*) The elevation control selsyn is connected to the elevation selsyn transformer for antenna positioning by K1202.

(*2*) The relays are energized for the remote method of operation and when energized the following connections are made:

(*a*) The azimuth transmitting selsyn of the director is connected to the azimuth selsyn transformer by K1201.

(*b*) The azimuth control selsyn and remote azimuth receiving selsyn are not connected.

(*c*) The elevation transmitting selsyn of the director is connected to the elevation selsyn transformer and the remote elevation receiving selsyn B1252 in parallel by K1202.

(*d*) The elevation control selsyn is not connected.

d. Power Connections. Transformer T1201 supplies 6.3 volts ac for the dial lamps and for the director signal circuit (fig. 214). There are three lamps behind each dial and these lamps are on whenever the MAIN POWER switch is in the ON position. Transformer T1202 supplies 230 volts ac for use in the azimuth and elevation tracking unit as the 60-cycle manual tracking reference voltage. Excitation voltage is supplied to the primary of T1202 and the selsyns when the radar set is connected to the director or when the selsyn excitation jumper is connected between the outlet and receptacle A on the switch and data panel.

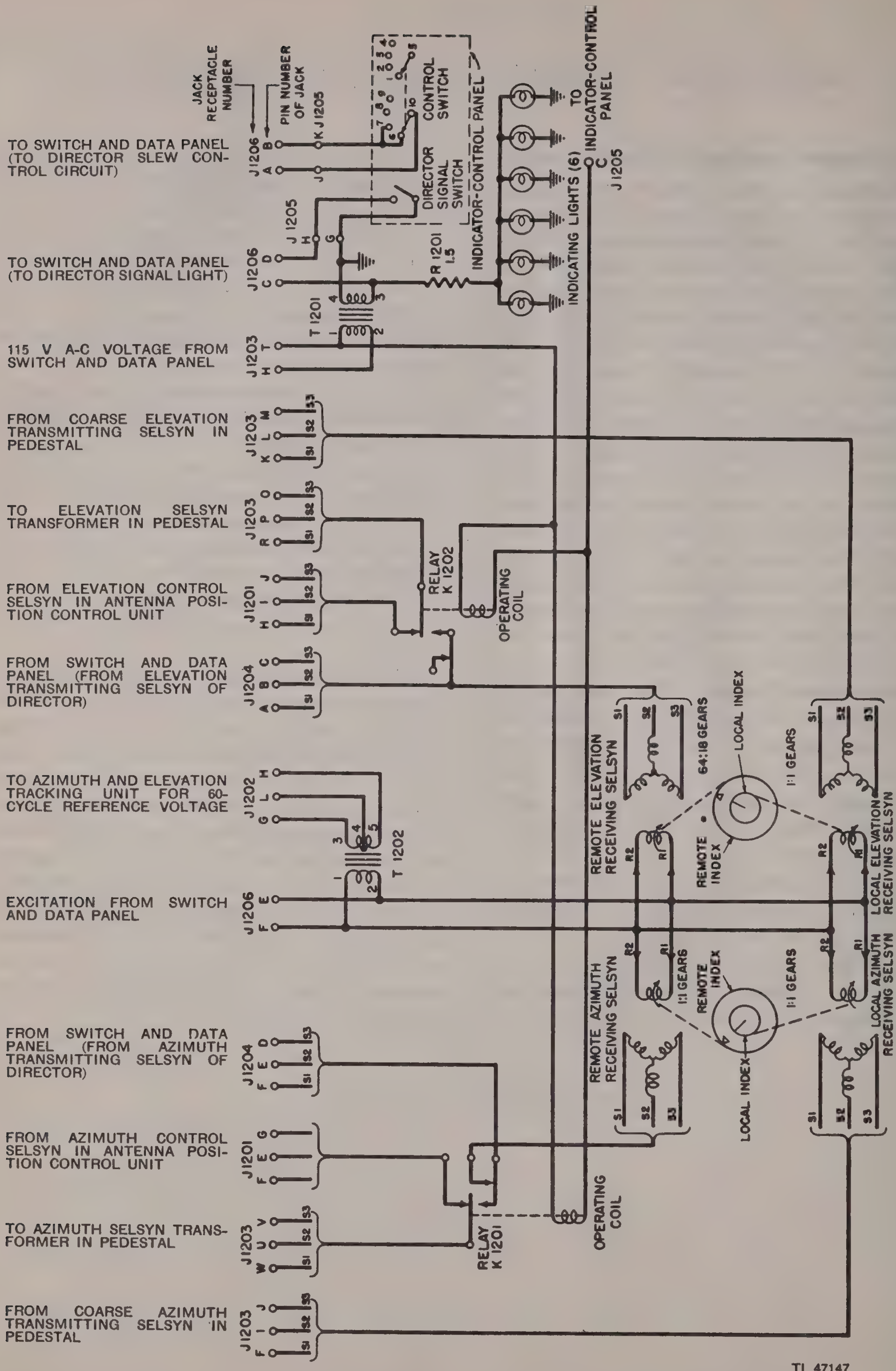

Figure 211. Antenna position indicator unit, simplified schematic diagram.

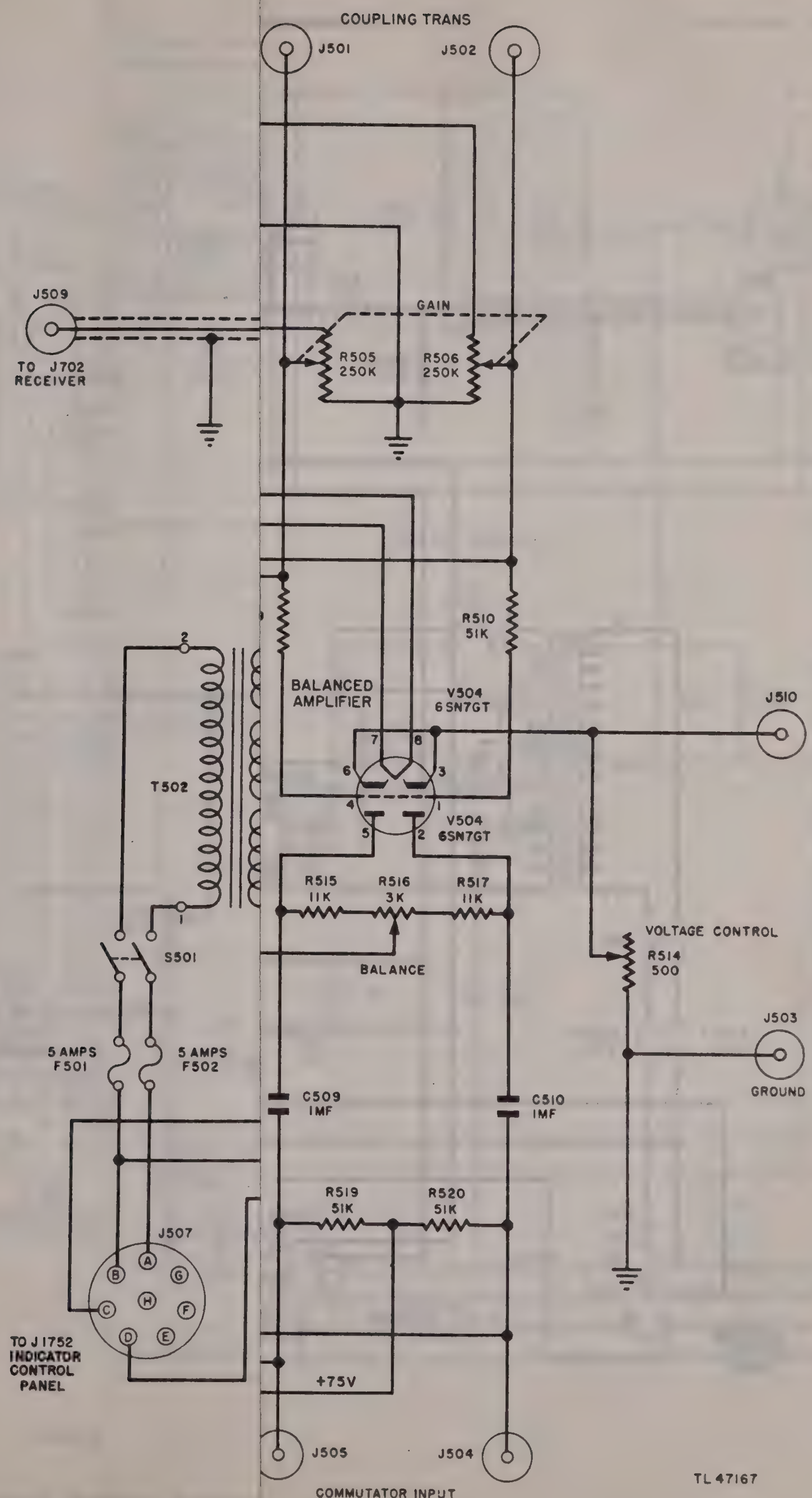

Figure 212. Automatic tracking unit, complete schematic diagram.

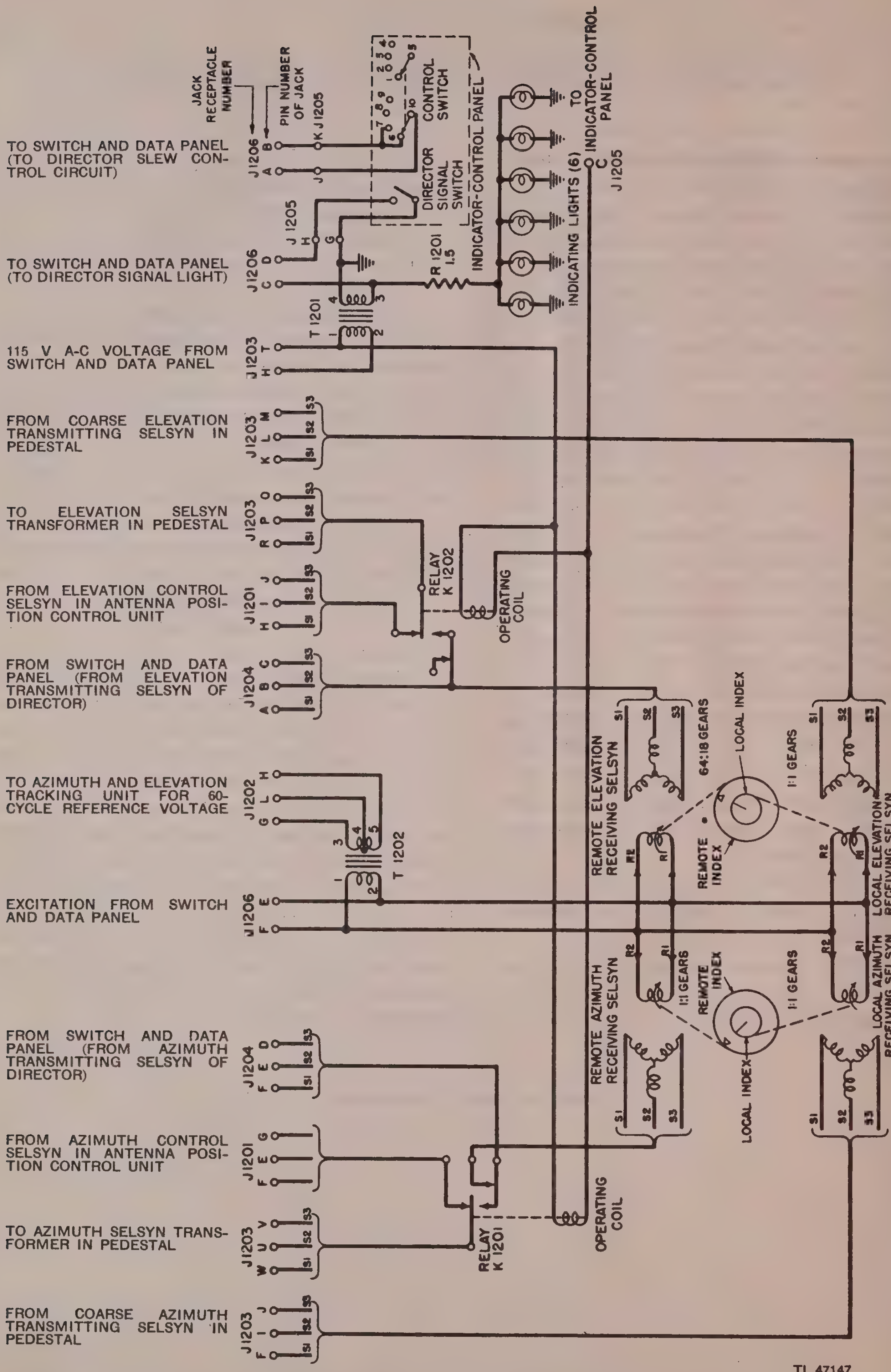

Figure 211. Antenna position indicator unit, simplified schematic diagram.

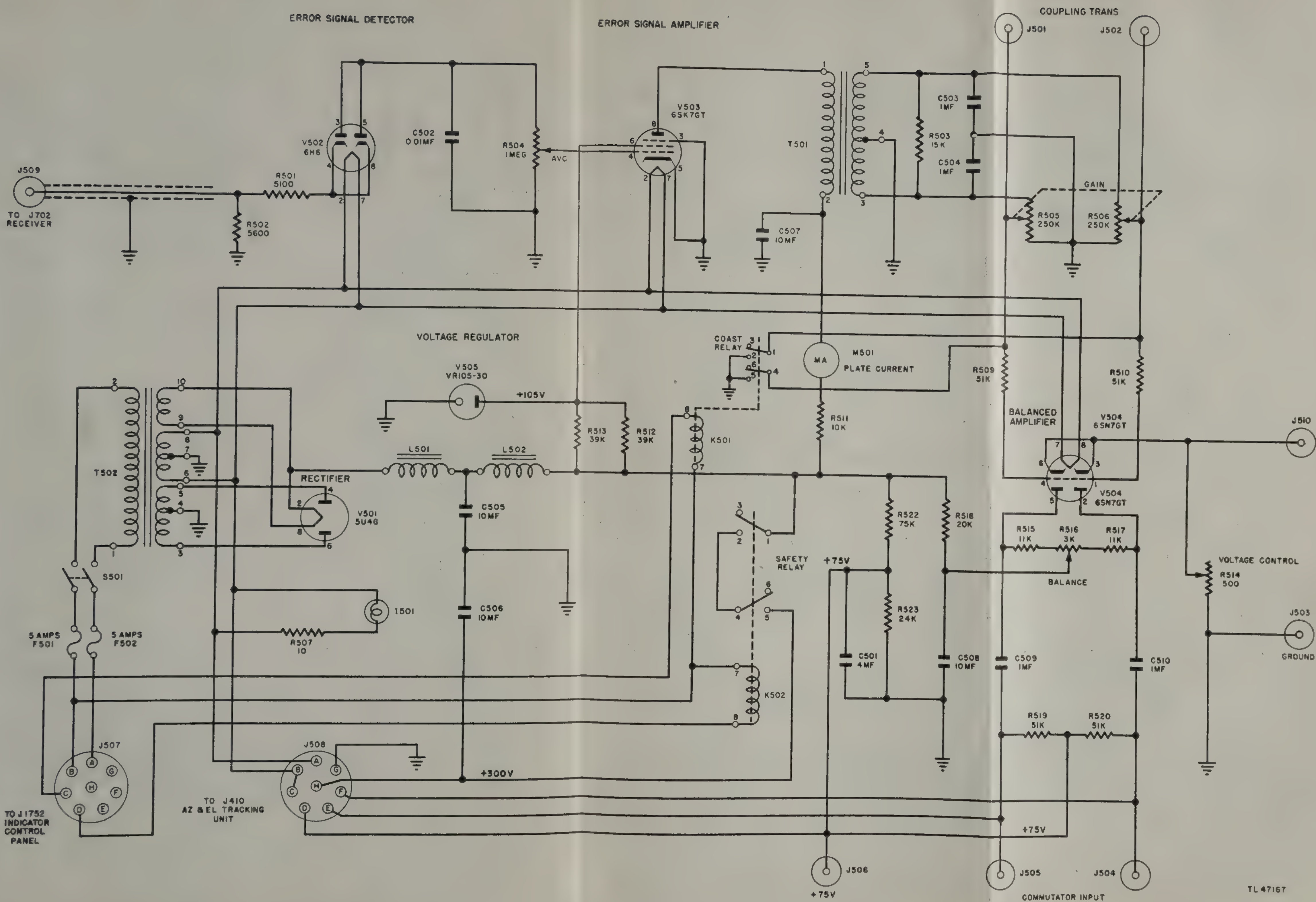

Figure 212. Automatic tracking unit, complete schematic diagram.

Figure 212. Automatic tracking unit, complete schematic diagram.

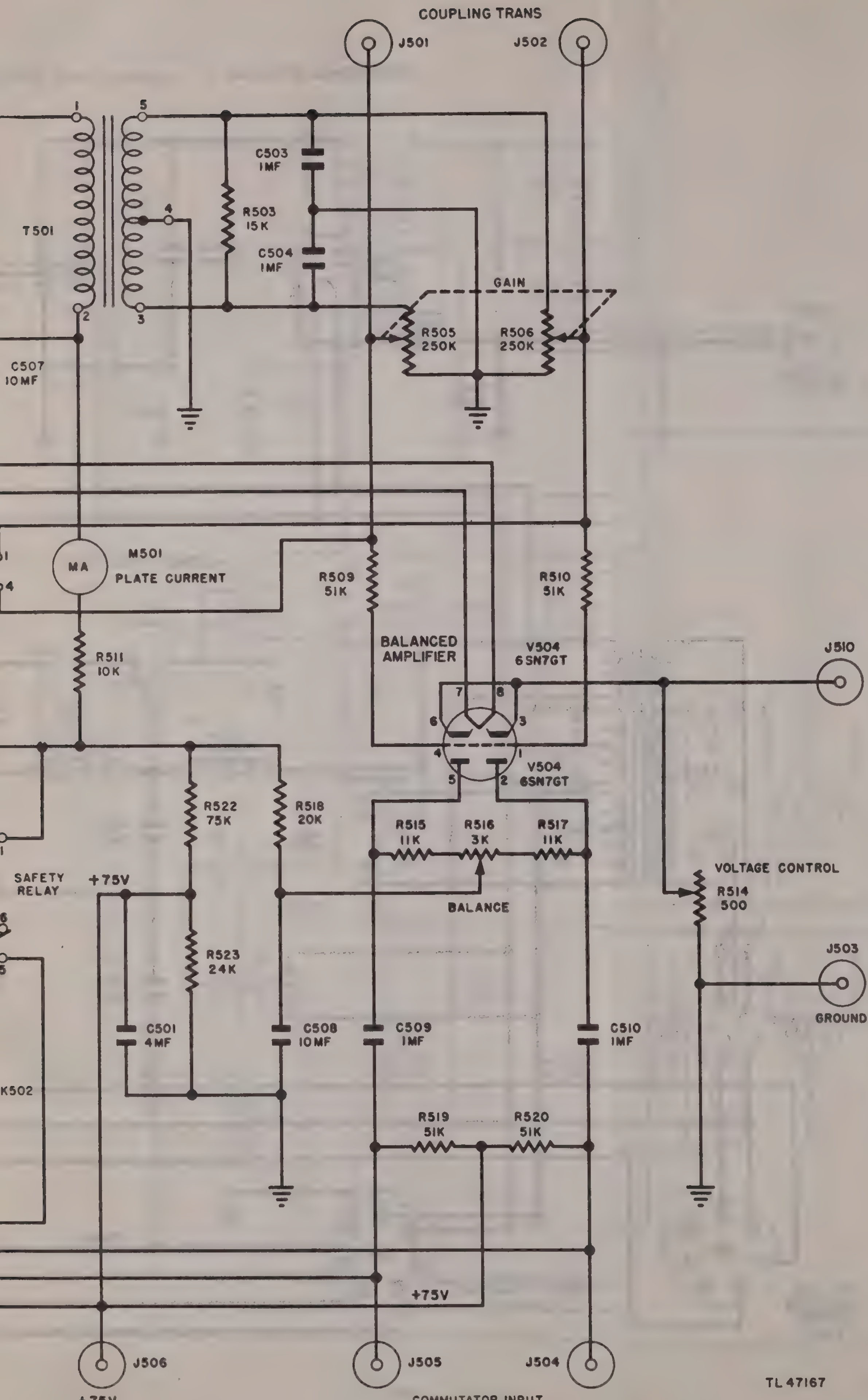

Figure 212. Automatic tracking unit, complete schematic diagram.

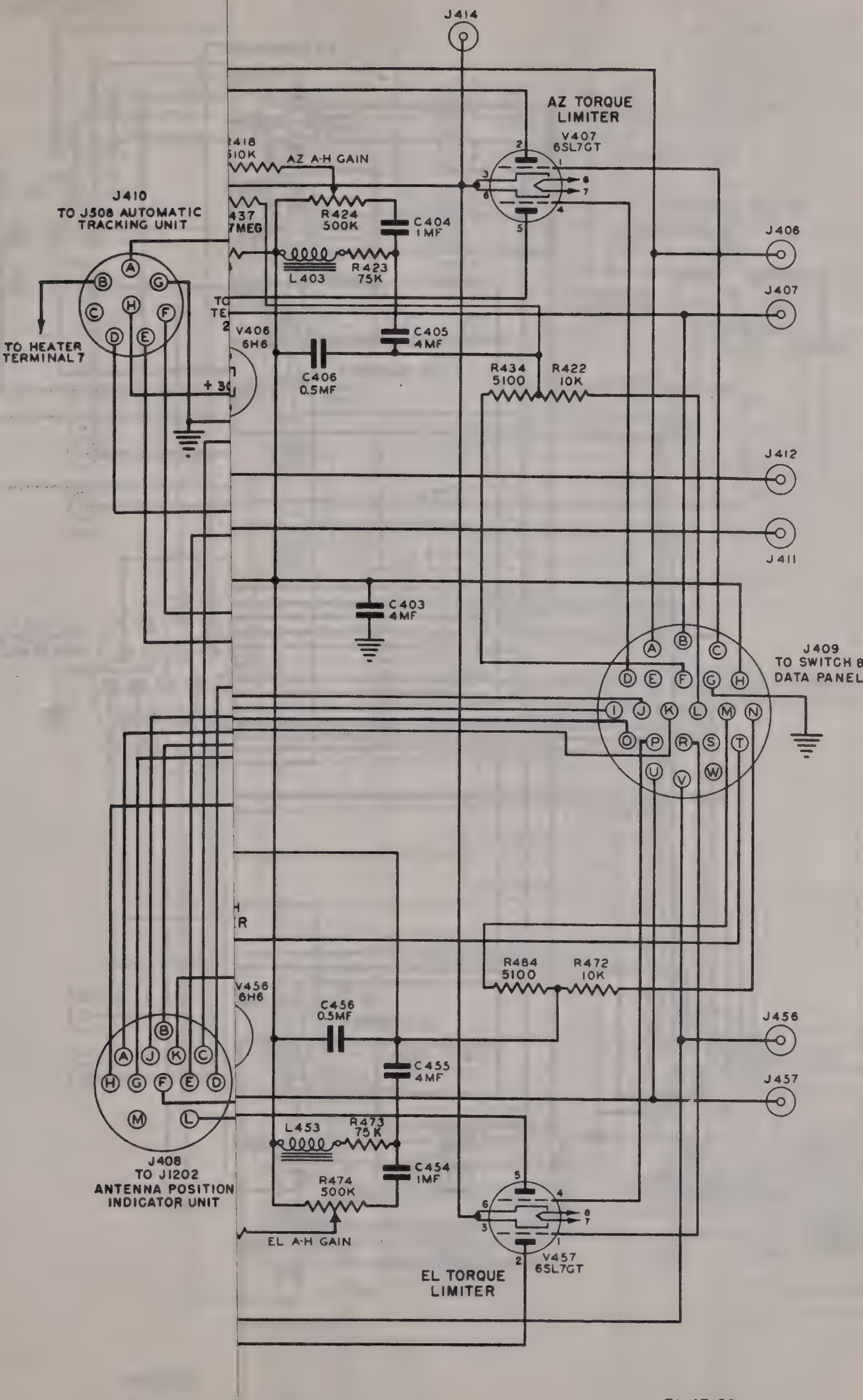

Figure 213. Azimuth and elevation tracking unit, complete schematic diagram.

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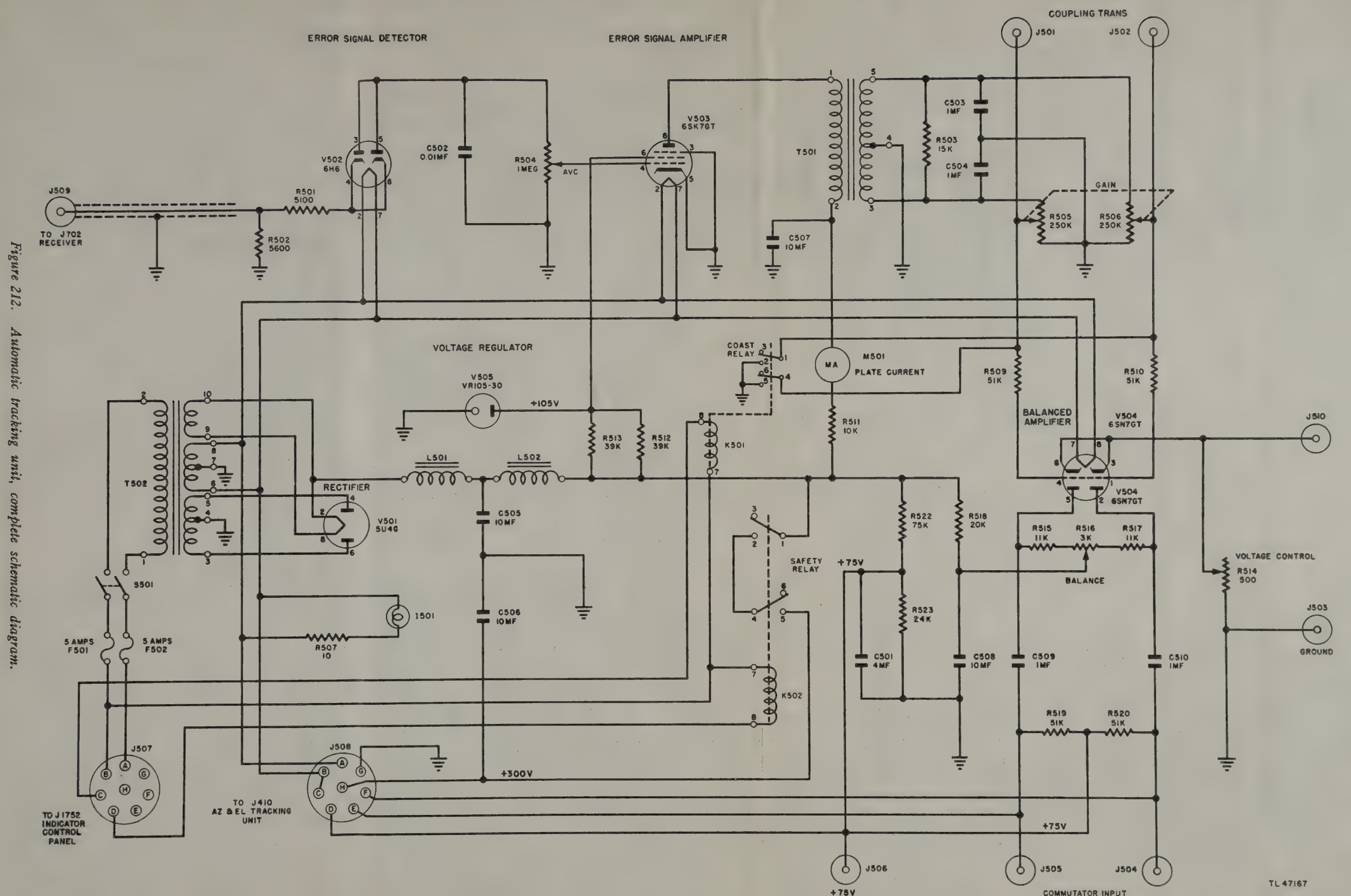

Figure 212. Automatic tracking unit, complete schematic diagram.

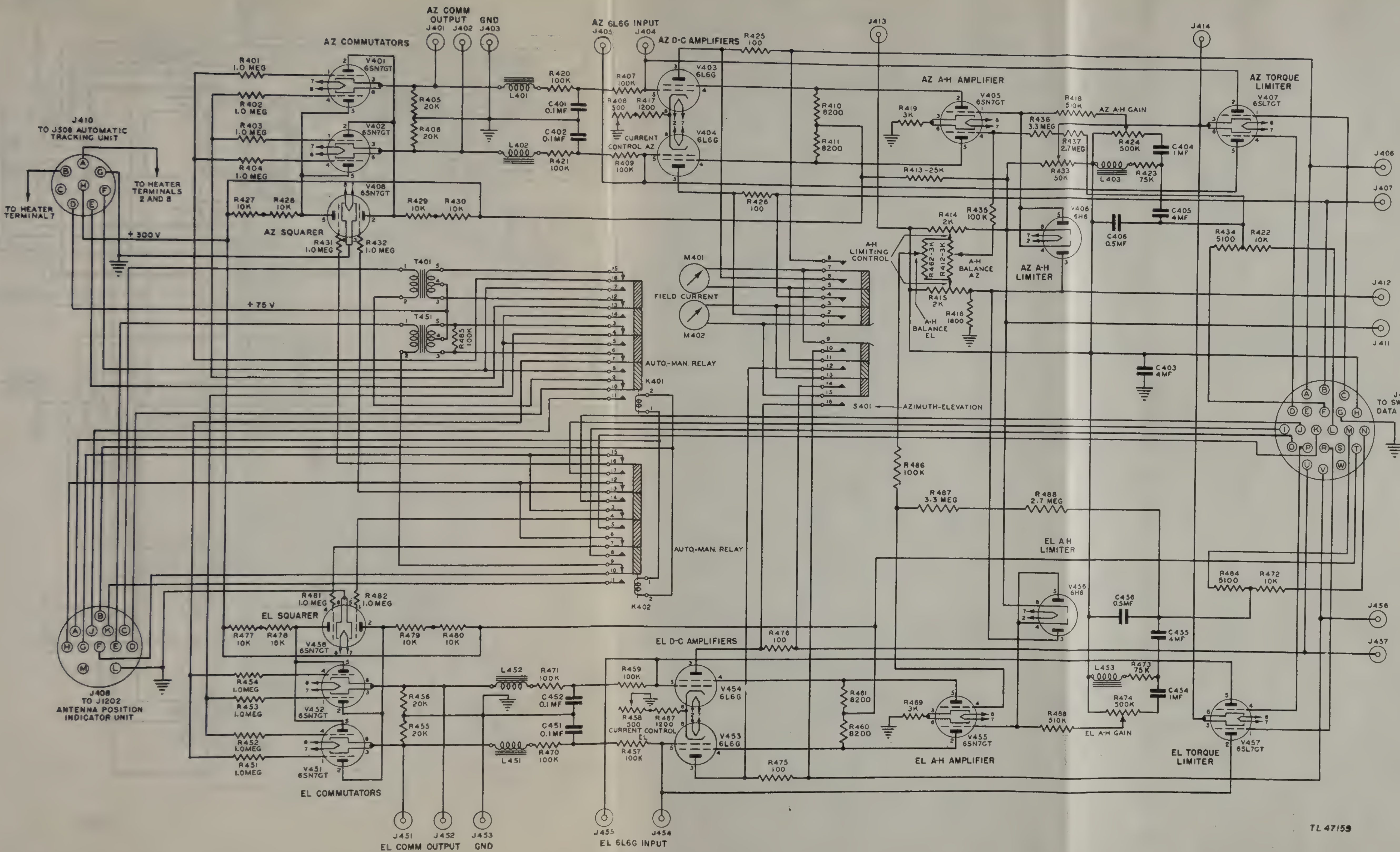

Figure 213. Azimuth and elevation tracking unit, complete schematic diagram.

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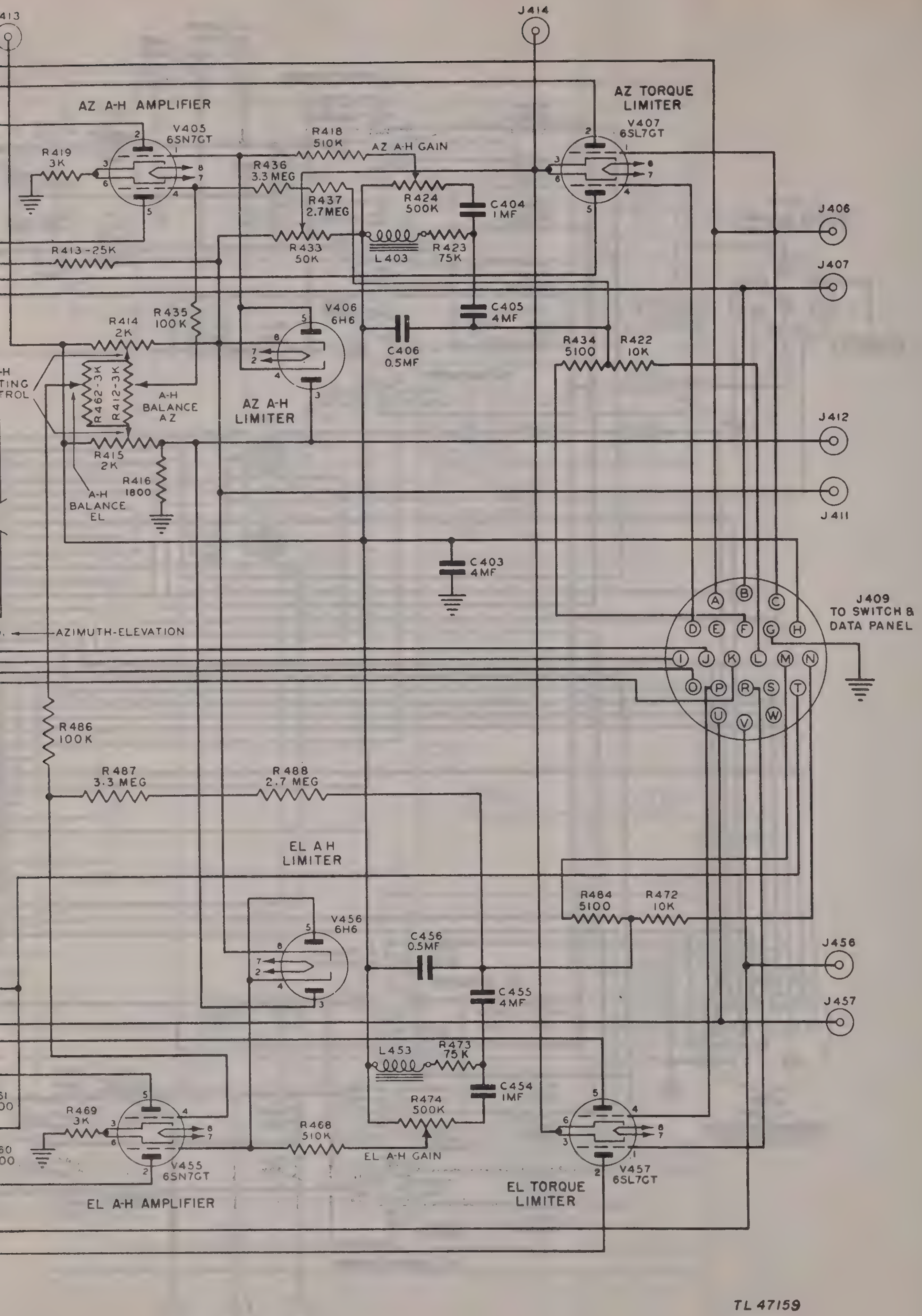

Figure 213. Azimuth and elevation tracking unit, complete schematic diagram.

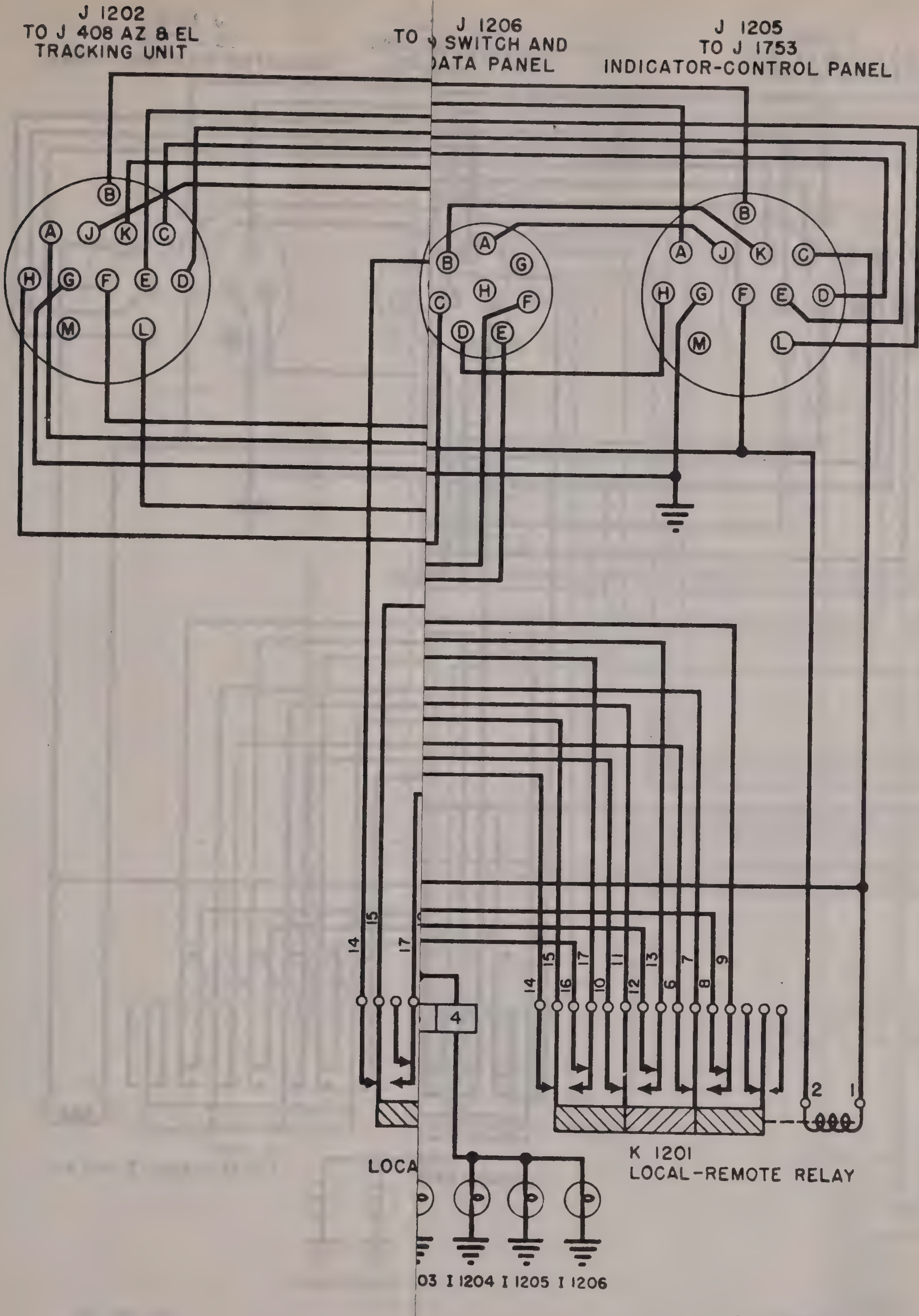

Figure 214. Antenna position indicator unit, complete schematic diagram.

Figure 213. Azimuth and elevation tracking unit, complete schematic diagram.

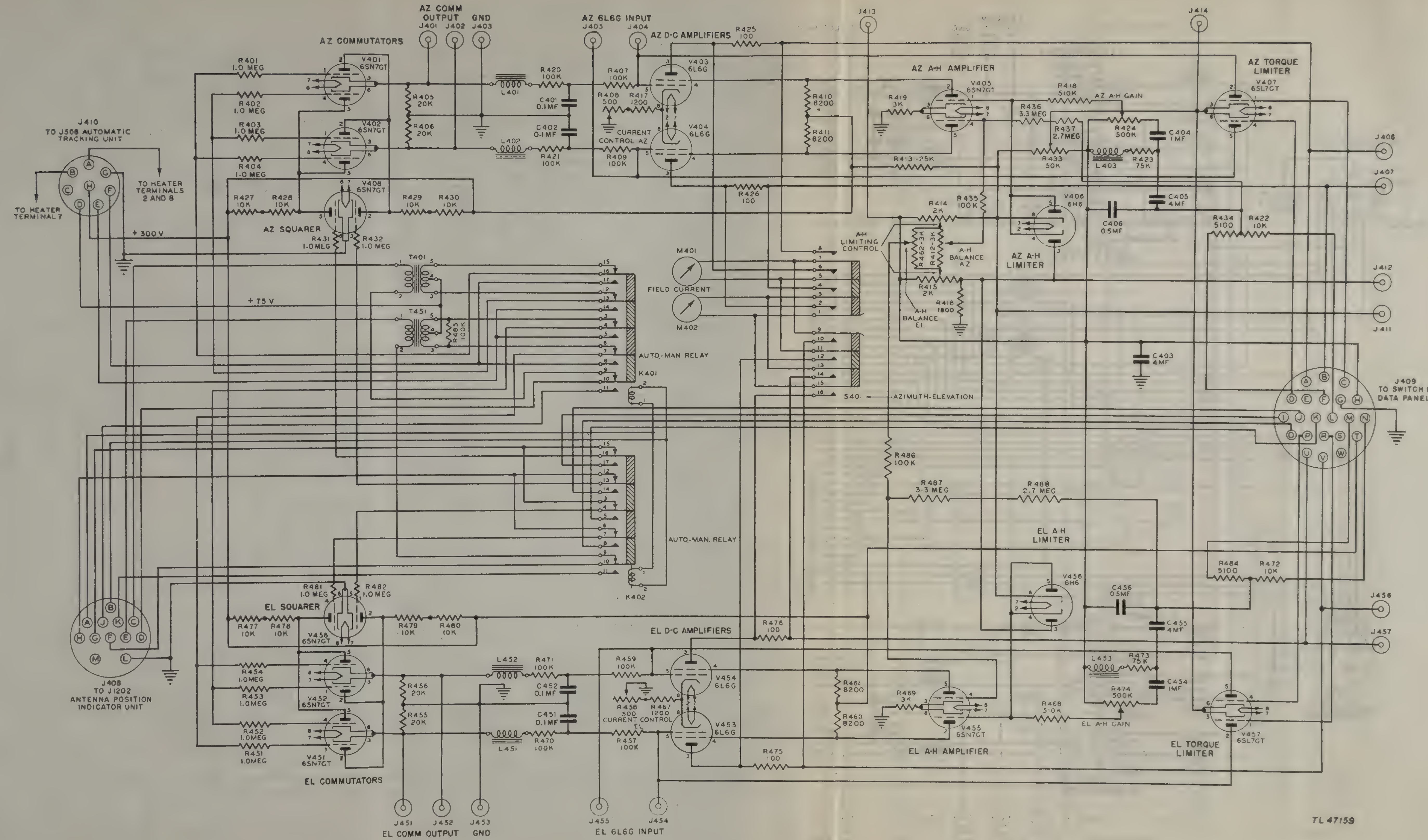

Figure 213. Azimuth and elevation tracking unit, complete schematic diagram.

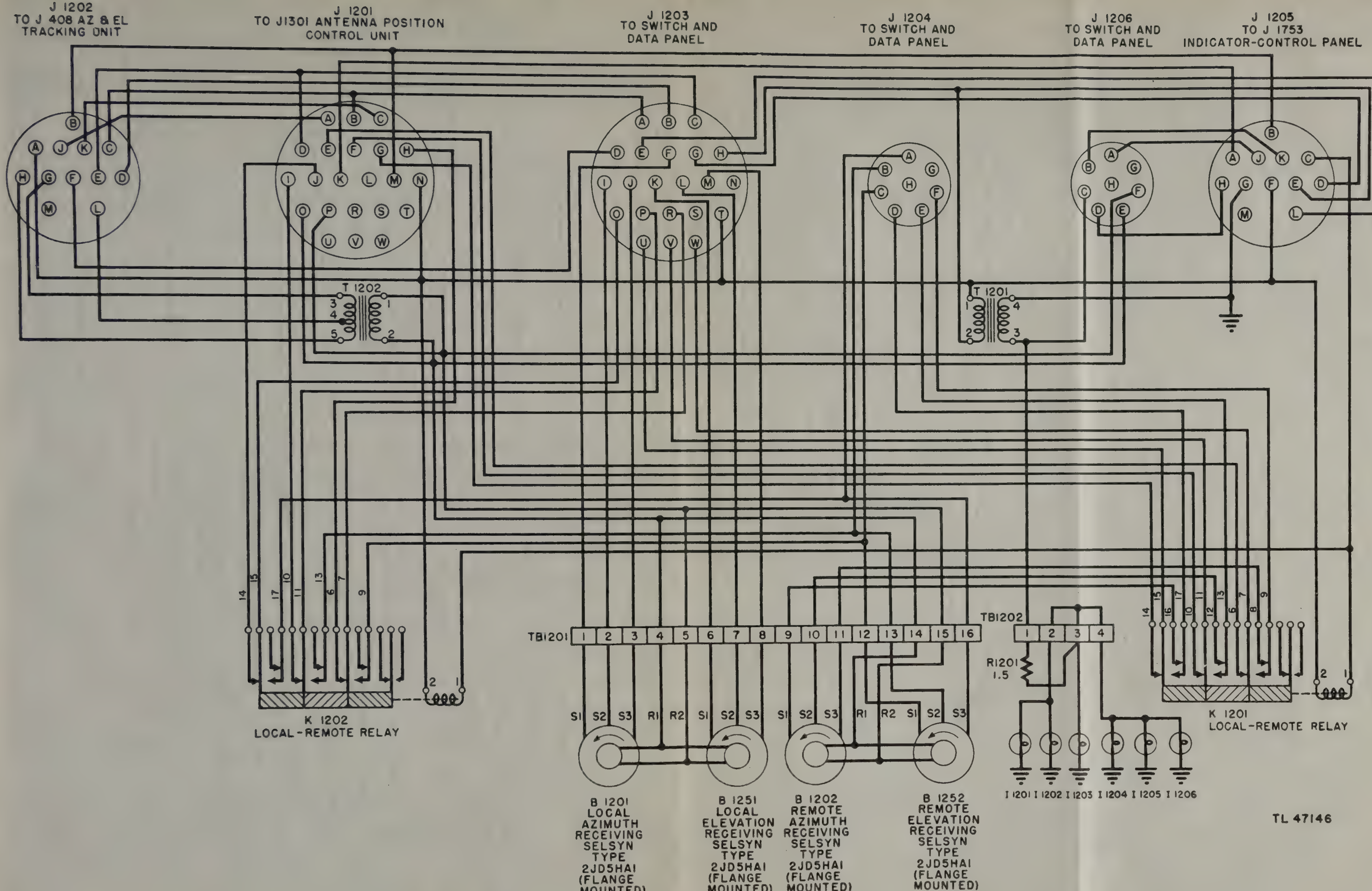

Figure 214. Antenna position indicator unit, complete schematic diagram.

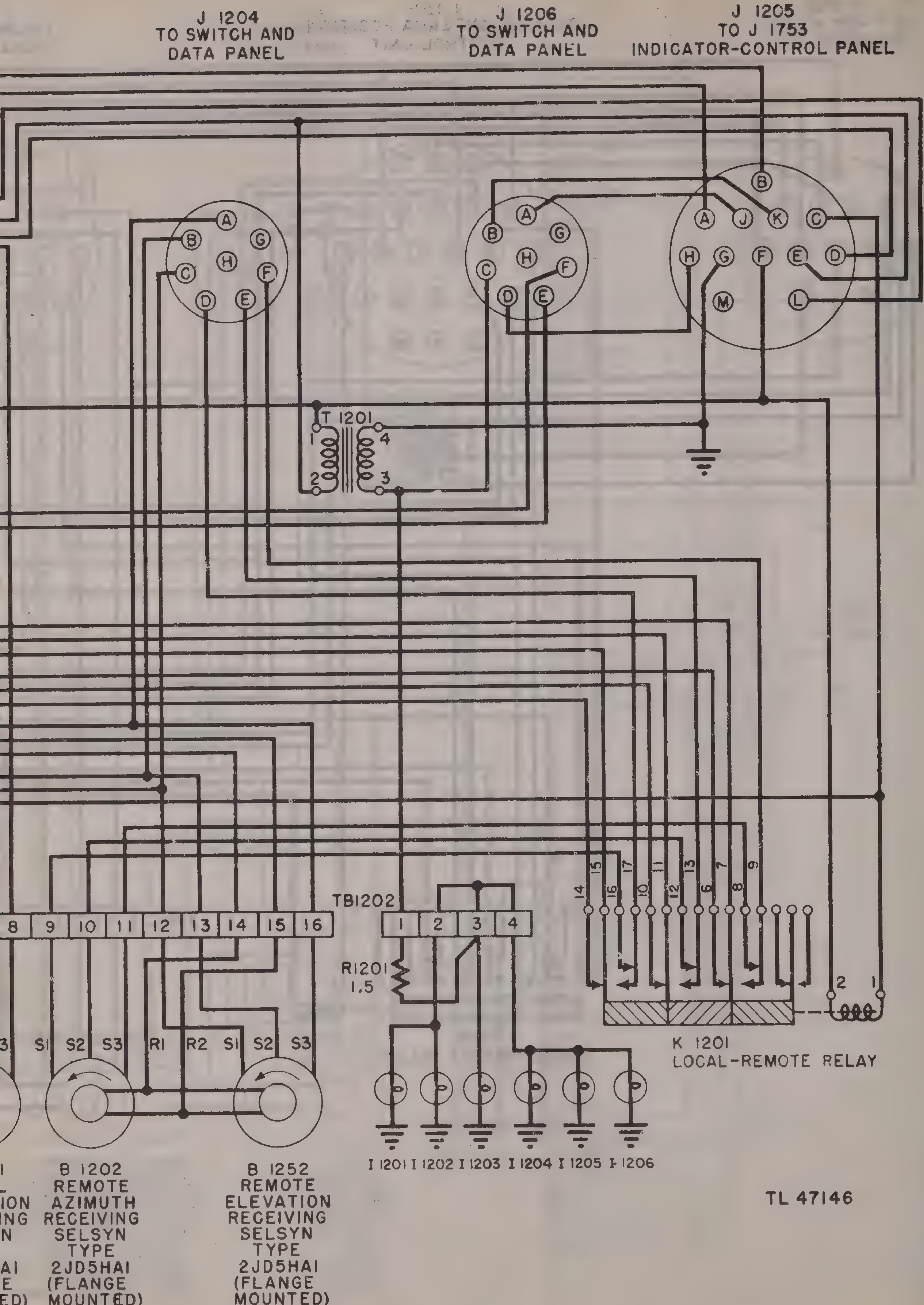

Figure 214. Antenna position indicator unit, complete schematic diagram.

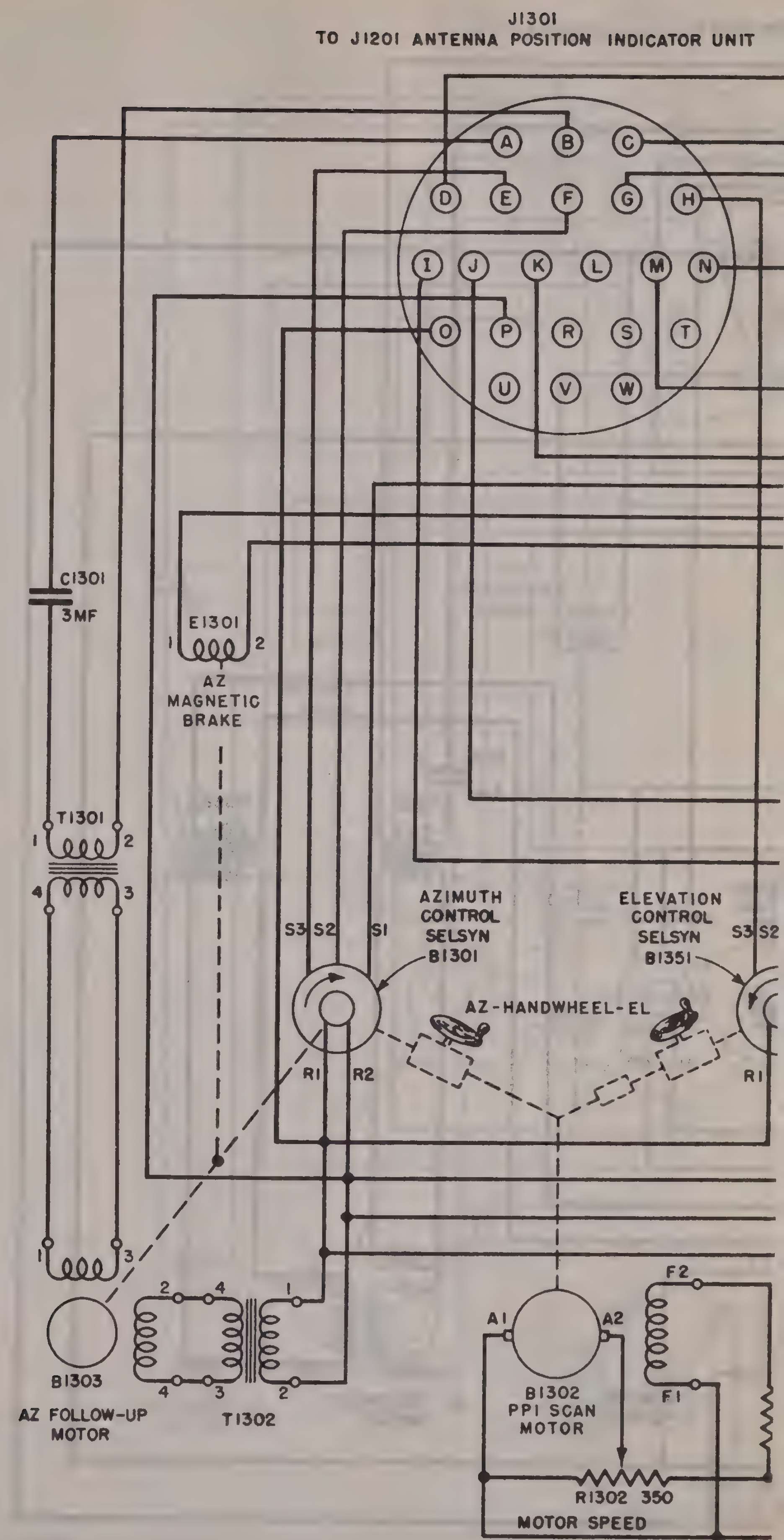

Figure 215. Antenna position control unit, schematic diagram.

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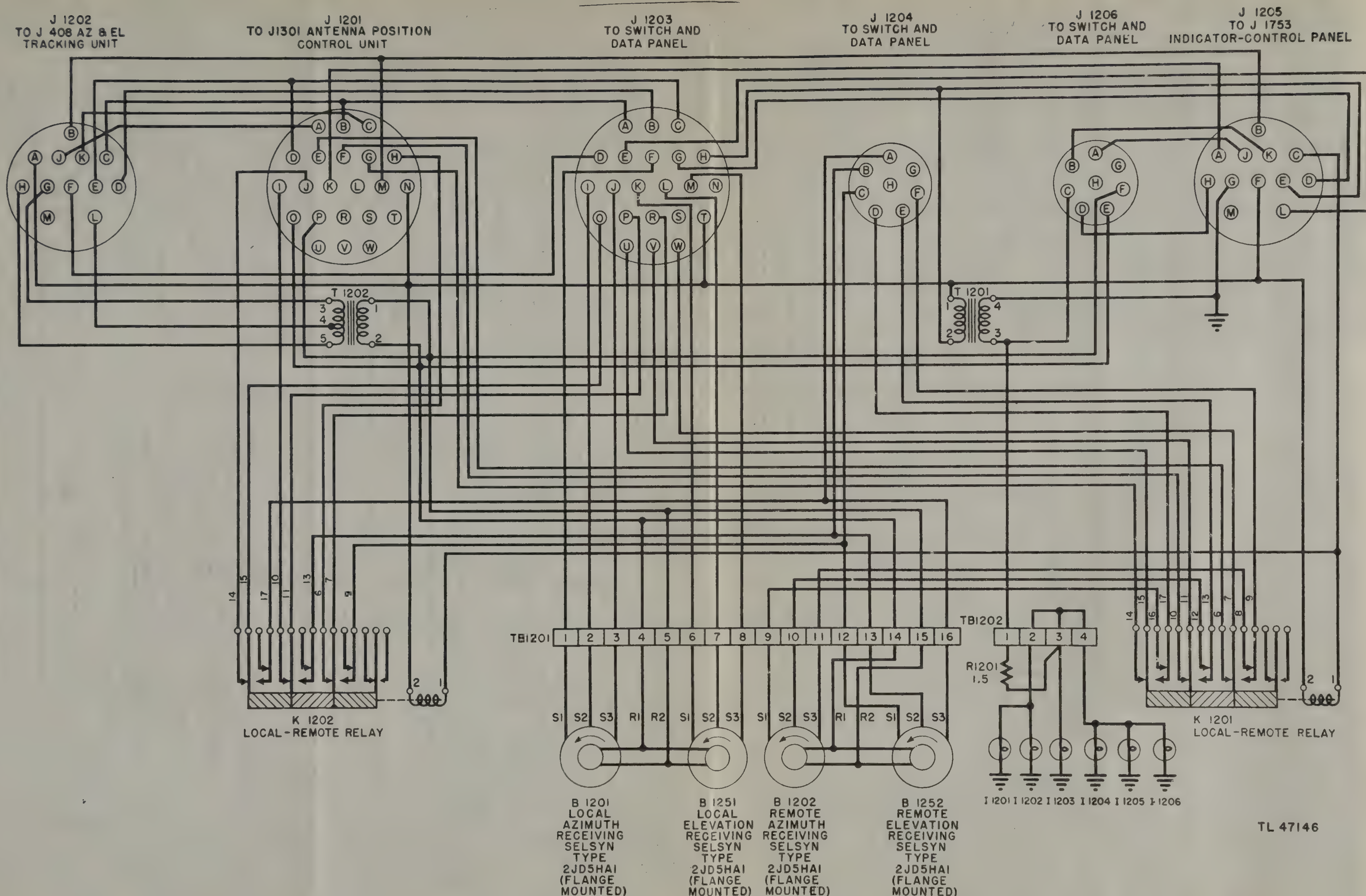

Figure 214. Antenna position indicator unit, complete schematic diagram.

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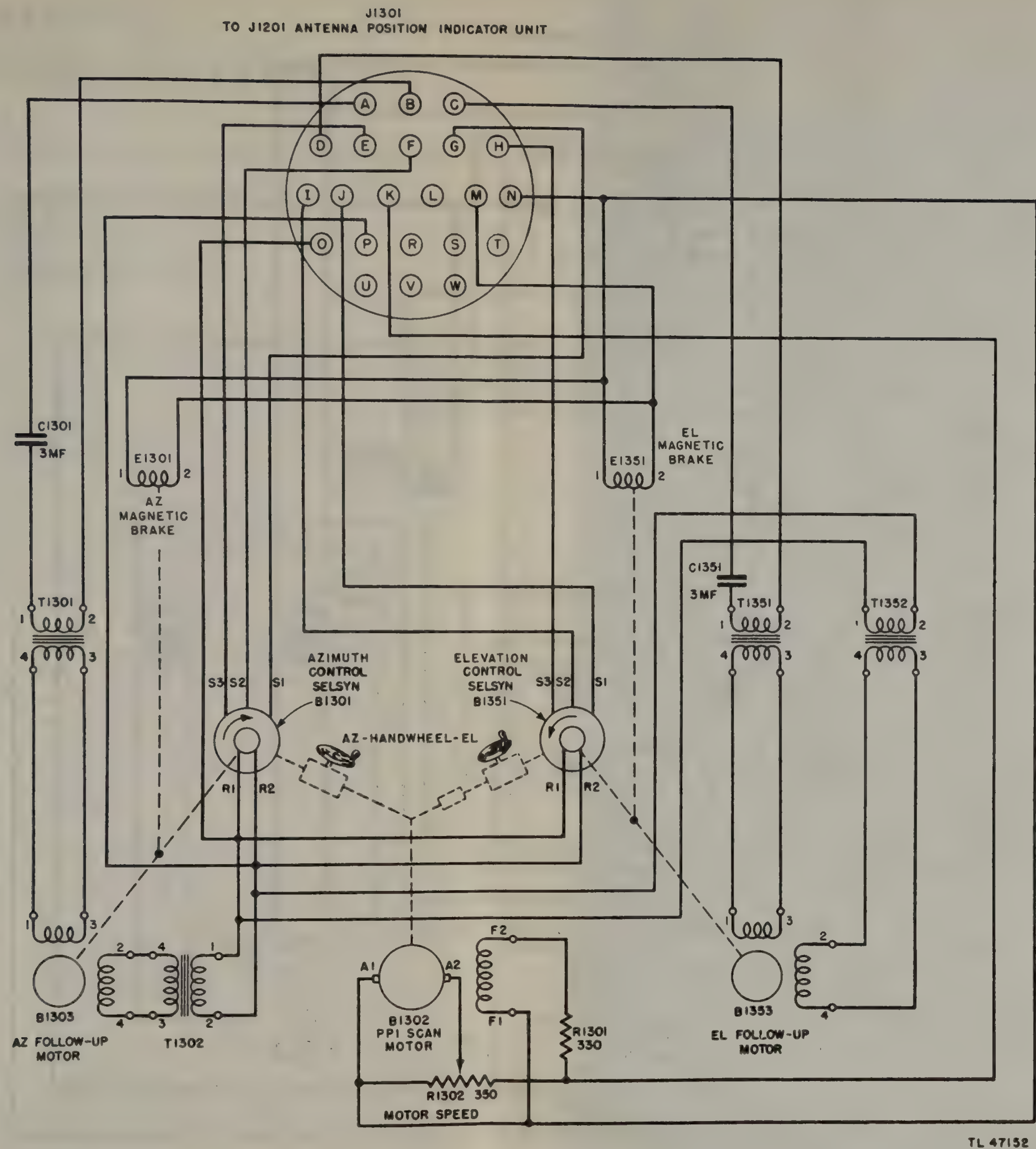

Figure 215. Antenna position control unit, schematic diagram.

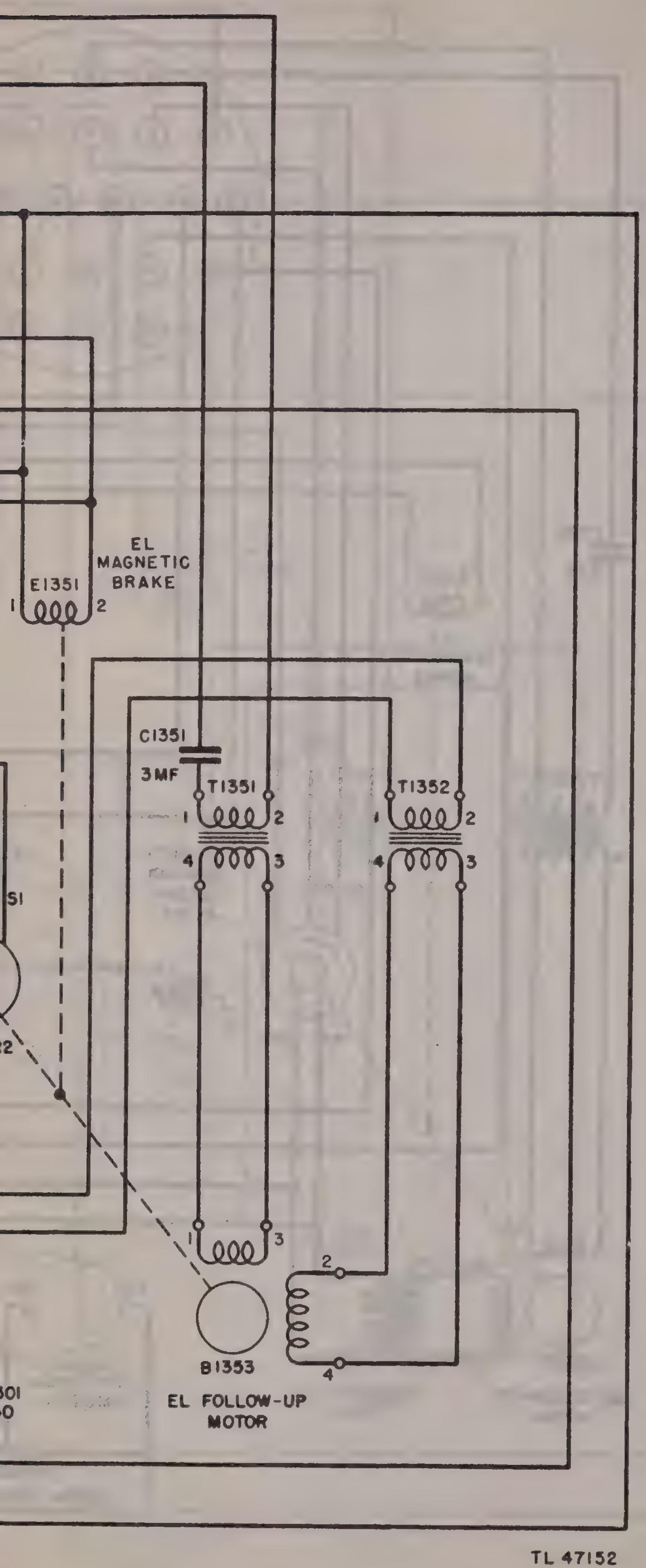

Figure 215. Antenna position control unit, schematic diagram.

CHAPTER 8
DATA TRANSMISSION SYSTEM

SECTION I
GENERAL DESCRIPTION

174. INTRODUCTION.

a. Those parts of Radio Set SCR-784 which convert the information learned about the target into a form which can be utilized to control the antiaircraft guns, are considered in this chapter. The parts that are involved are scattered through the entire set. Primarily, provision is made for two types of gun directors: the M4 and M7, which have mechanical computing mechanisms; and the M9 and M10, which have electrical computing circuits and mechanical trackers.

b. The SCR-784 is equipped to supply both mechanical data (by electrical means with selsyns) and electrical data (voltages proportional to the data determined with potentiometers). Because only one end of some of these data transmitting systems is found in the set, some consideration of what is in the gun directors must be made. The understanding of the various data devices and systems is a requirement of the radar repairman because he is responsible for the proper operation of the SCR-784 and is, therefore, called upon to assist in the alignment and orientation of the data transmission system, to help shoot trouble on the system, and to make repairs or replacements of those devices which are located in the set.

175. COMPONENTS.

The components of the data transmission system are shown in the data flow diagram (fig. 216). The pedestal contains the potentiometers and selsyns which transmit data proportional to the azimuth and elevation angle of a target. The selsyn information is transmitted to the antenna position indicator which shows the azimuth and elevation settings of the SCR-784 antenna and the gun director telescopes. Coarse and fine selsyn data is also transmitted to the gun director from the antenna of the set through receptacle B. Azimuth potentiometer data on the position of the SCR-784 antenna is transmitted to the gun director through receptacle D. Depending on the position of the altitude-slant range switch on the switch and data panel, the slant range data is transmitted directly to the gun director through receptacle C or to the altitude converter system. The elevation potentiometer data can be sent also either to the altitude converter system or directly to the gun director. When the altitude-slant range switch is in the ALTITUDE position the slant range and elevation angle data are combined in the altitude converter system to produce selsyn data proportional to the altitude of the target. The altitude data is fed to the M4 or M7 gun directors through receptacle B.

176. INFORMATION TRANSMITTED.

a. In Radio Set SCR-784 angles are measured in mils (a special artillery unit) and distances are measured in yards. The mil is a unit of angular measurement which is smaller than a degree, there being 6,400 mils in a complete circle. This makes the mil a convenient unit for artillery work because it need not be subdivided.

b. The data of the SCR-784 is also designated as present position data. The designation present, means that the data from the set is the true data of the target position at every instant. In contrast to this, the gun director produces the predicted data by means of which the guns are aimed slightly ahead of the target to allow for the time lapse in the firing and travel of the shell.

Figure 215. Antenna position control unit, schematic diagram.

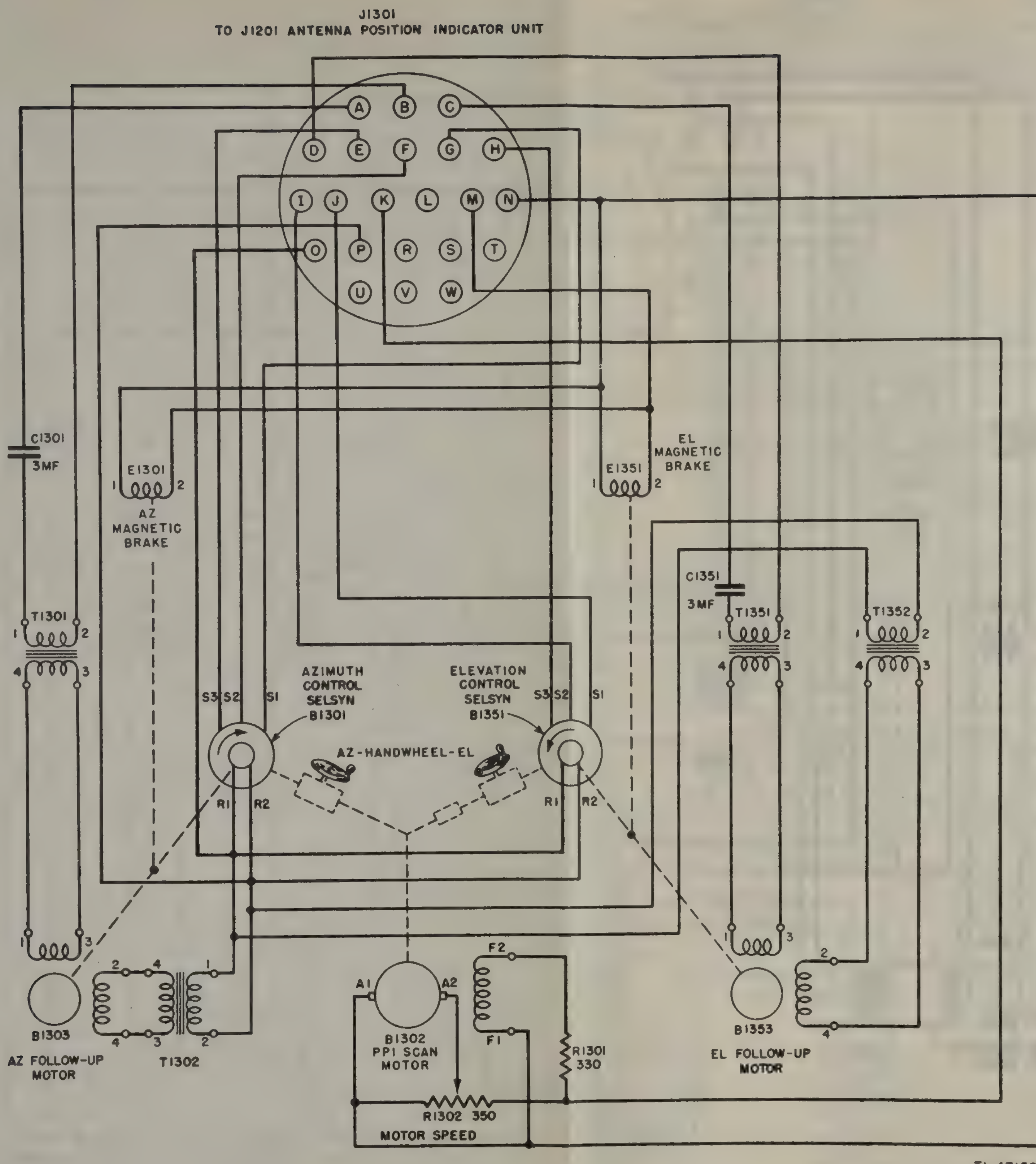

Figure 215. Antenna position control unit, schematic diagram.

CHAPTER 8
DATA TRANSMISSION SYSTEM

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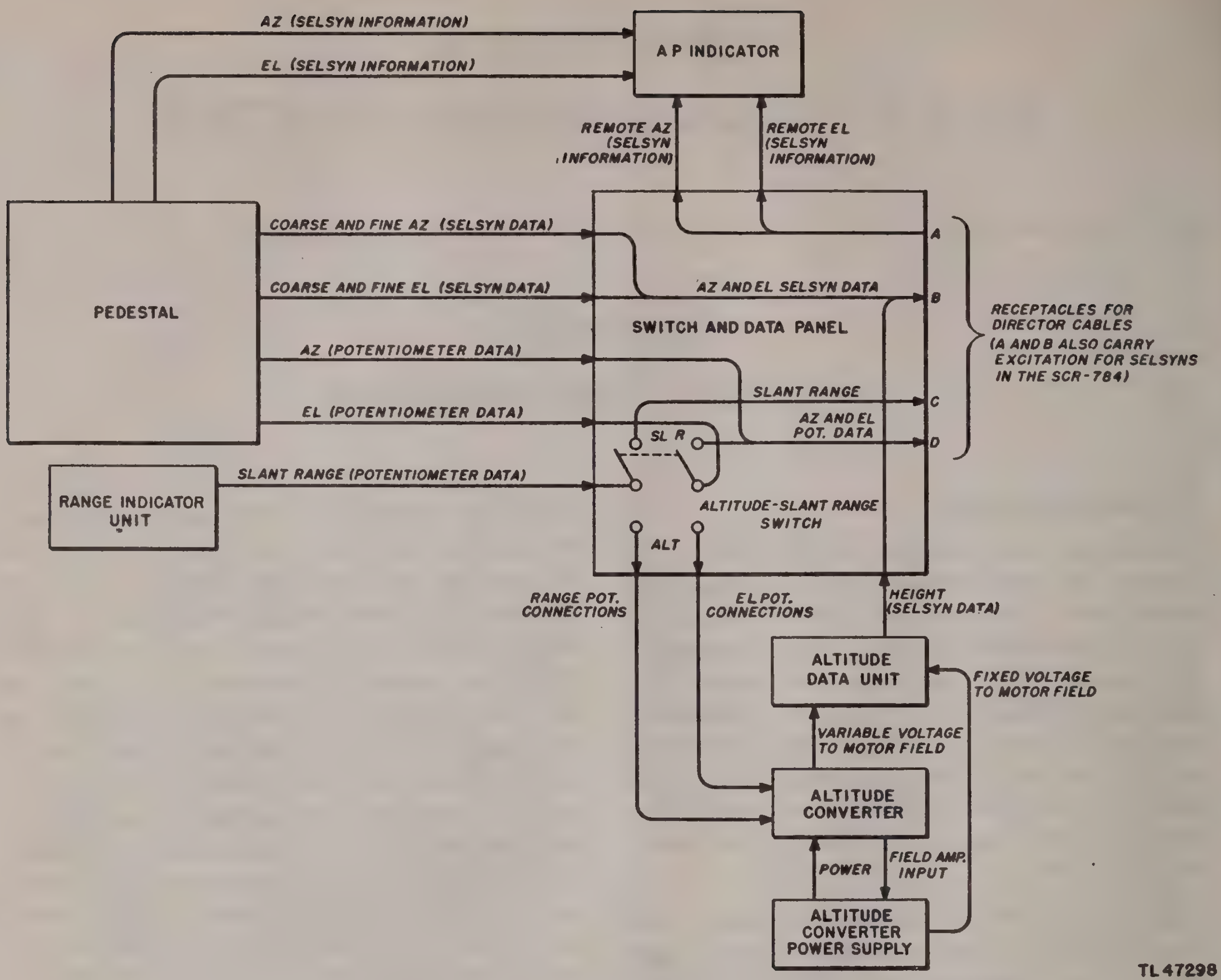

Figure 216. Data flow diagram.

177. TARGET LOCATION.

a. Radio Set SCR-784. In common with all radar sets used for gun-laying, searchlight control, or height-finding, the SCR-784 locates a target with three basic measurements. These are azimuth angle, elevation angle, and slant range, shown in figure 217. The data transmission system, however, contains units which convert these measurements into others required by the directors in use at present.

b. M4 or M7 Gun Directors. These mechanical directors require azimuth angle, elevation angle, and altitude or slant range (fig. 218) as selsyn data. The first two can be obtained from mechanical connection to the reflector, but the altitude must be computed from the slant range and elevation angle or the slant range changed from potentiometer to selsyn data by the altitude conversion units described in section IV of this chapter.

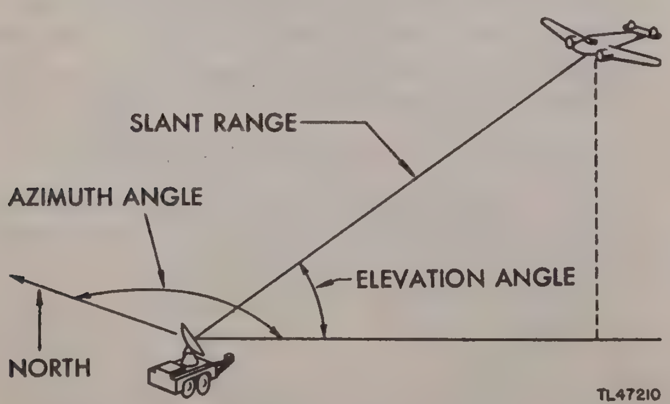

Figure 217. Target location by SCR-784.

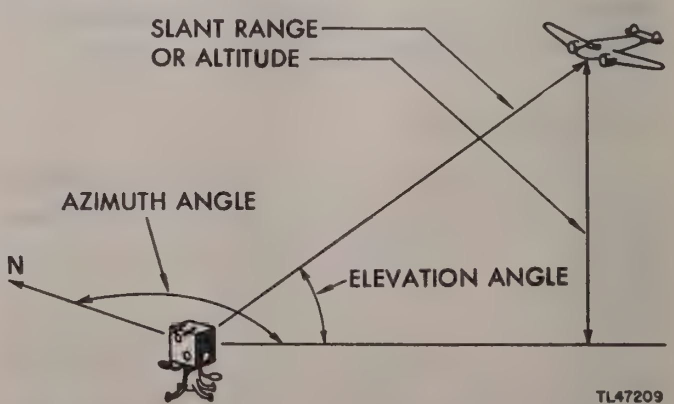

Figure 218. Data required by M4 or M7 gun directors.

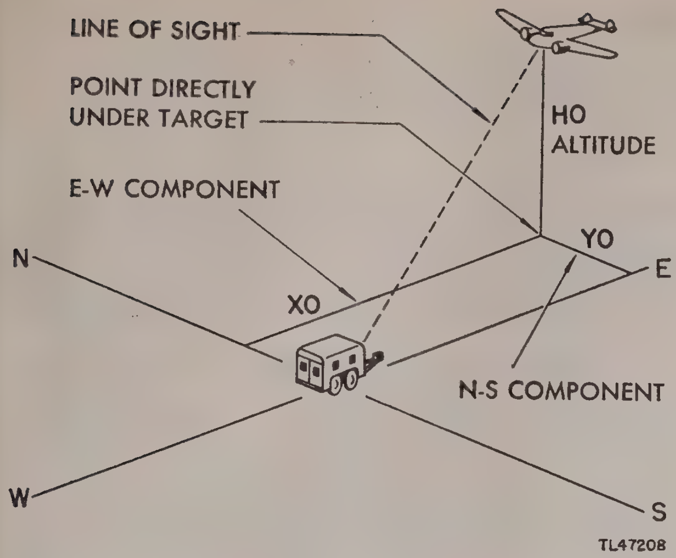

Figure 219. Data required by M9 or M10 gun directors.

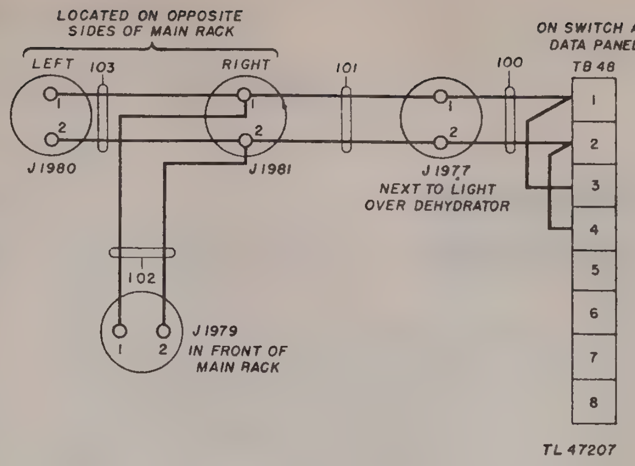

Figure 220. Interphone circuit.

c. M9 or M10 Gun Directors. The three elements of data required by the M9 and M10 directors are illustrated in figure 219. The target is located by a method similar to that used on military maps, that is, distances north or south, and east or west from a reference point, and altitude. In this case the reference point is the radar set.

178. SWITCH AND DATA PANEL.

The switch and data panel (fig. 10) is the connection box for the cables to the director and the terminating place for all the data devices of the SCR-784. The wiring of the panel is shown in the control circuit schematic diagram (fig. 260).

a. Slant Range-altitude Switch. The panel contains an eight-pole double-throw switch S1907 which connects the range and elevation potentiometers from the regular data connections to operate with the altitude converter. When the M9, M10, or similar type director is supplied with data, the switch should be in the SLANT RANGE position. When the M4 or M7 gun director is supplied with data, the switch should be in the ALTITUDE position.

b. Main Power Input. The main power receptacle for the incoming 115-volt 3-phase supply is located on the switch and data panel and designated J1906 in figure 260. The main power receptacle is connected directly to the MAIN LINE switch S1901, to the DEHYDRATOR MOTOR switch S1908, and through fuses F1910 and F1911, to the 115-volt receptacles throughout the trailer. From the main line switch the power goes through the line voltage regulator to terminal boards TB47-1, TB47-2, and TB47-3. From these terminal boards power is distributed to all other components of the SCR-784.

c. Selsyn Excitation. Lamp I1901 and switch S1906 are provided to illuminate the data panel to make the cable and the telephone line connections. A standard duplex outlet is also provided to supply voltage for a trouble light or soldering iron. This outlet is used also to obtain voltage for exciting the selsyns of the SCR-784 when the set is not connected to a director. When used for gun laying all selsyn excitation for the SCR-784 comes from the director and the operation of certain parts of the antenna positioning equipment depends upon the 115-volt 60-cycle selsyn excitation obtained from the director. To provide for operation as a search set only, or for testing the SCR-784 without a director, a short selsyn excitation jumper cable is furnished to take voltage from the outlet and supply it to the proper terminals of receptacle A J1901.

d. Telephone Connections (fig. 220). Terminal block TB48 on the switch and data panel provides connections for four telephone cable pairs. The terminals 1 and 2 in parallel with terminals 3 and 4 of TB48 connect to the interphone circuit which has two outlets in the trailer and one outlet on each side of the main rack.

SECTION II
SELSYN DATA SYSTEM

179. INTRODUCTION.

a. Data Transmitted. With the M4 or M7 directors only selsyn data is transmitted, but the range potentiometer and elevation potentiometer data is used in the altitude conversion system. The cable connections to the director are shown in a simple cabling diagram (fig. 221). In the block diagram (fig. 222), the pin numbers of the cable connections are shown. For operation with this type of director, switch S1907 on the switch and data panel must be in the ALTITUDE position. When the switch is in this position the range potentiometer is disconnected from receptacle C on the switch and data panel and is connected to the altitude converter (fig. 216). The elevation potentiometer is disconnected from receptacle D on the switch and data panel and is connected to the altitude converter. The information which is transmitted to the director is fine and coarse azimuth, fine and coarse elevation, and altitude. The direction in which the director telescopes are pointing is transmitted from the director to the antenna position indicator unit remote dials. The selsyn excitation voltage and director signal switch are also connected to the SCR-784.

b. Altitude Conversion System. The altitude conversion system produces a voltage proportional to the altitude of the target. This voltage is then measured automatically and a proportional mechanical movement is transmitted to the director. A switch on the indicator and control panel allows slant range to be transmitted by the altitude selsyn when the angle of elevation of a target is low.

c. Local and Remote Operation.

(*1*) Figure 222 shows the connections when the control switch is in the PPI scan, manual, or automatic positions. On any of these positions the local-remote relay is in the local (L) position.

(*2*) Remote operation of Radio Set SCR-784 with the M7 type gun director is accomplished by merely turning the CONTROL

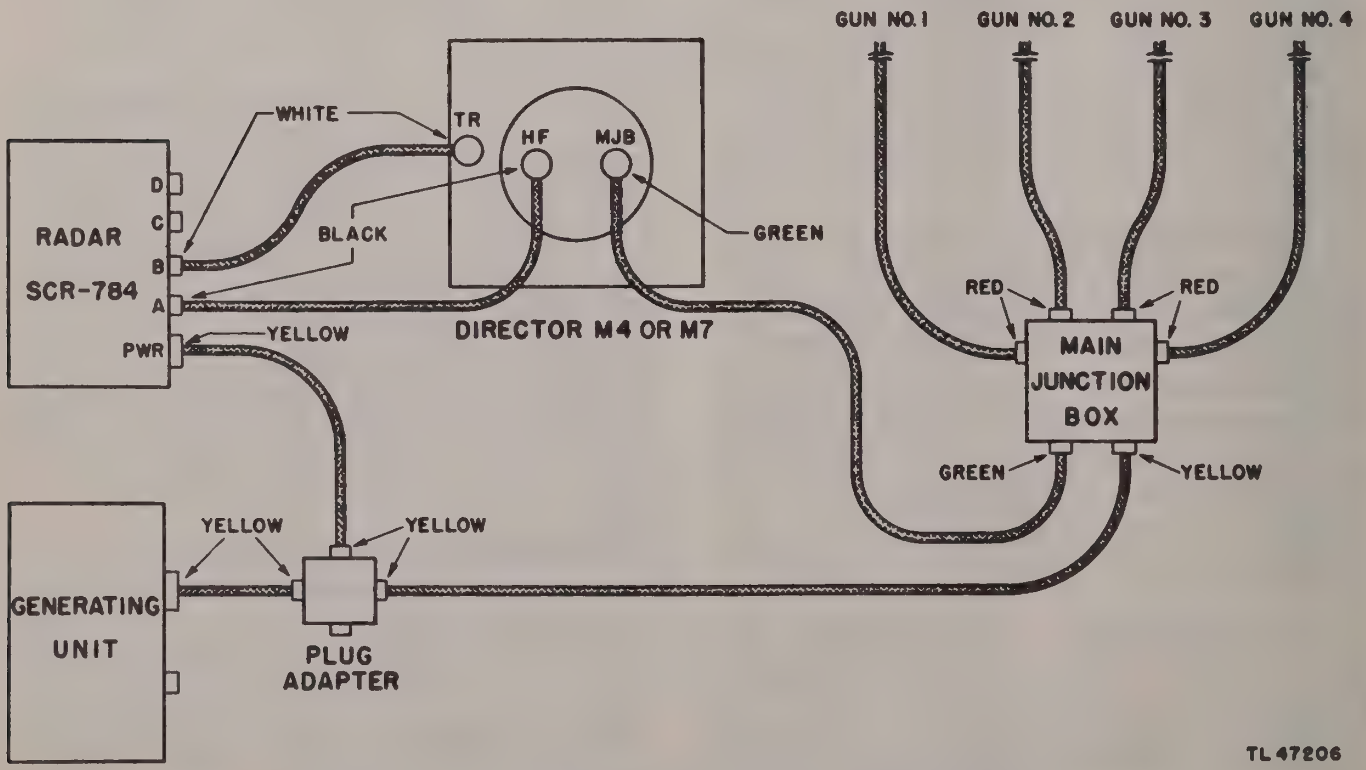

Figure 221. Gun directors M4 or M7, cable connections.

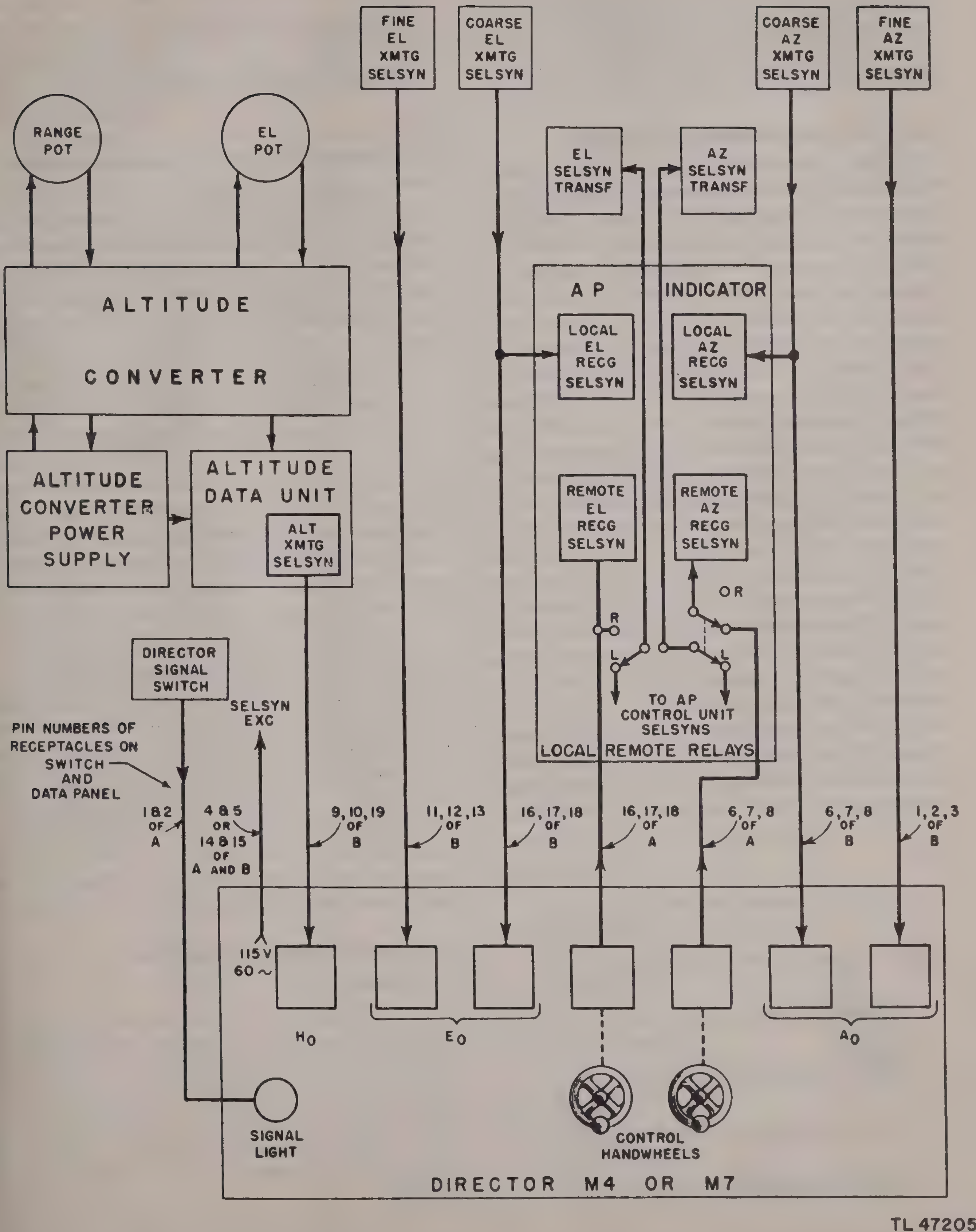

Figure 222. Tracking with M4 or M7 gun directors, block diagram.

SWITCH on the indicator-control panel to the REMOTE position. The block diagram indicates the changes of connections which take place when this is done as the local-remote switch is in the REMOTE position. In this type of operation the SCR-784 operators track manually or automatically in range but do not track in azimuth or elevation.

180. DATA TRANSMISSION SELSYNS.

The data transmission system includes seven transmitting selsyns and four receiving selsyns of the total of 16 selsyns in the SCR-784; the other five are used in the antenna positioning and PPI systems. Two of the transmitting selsyns are connected to transmit slant range data and at present are not used with any director. These are useful only as emergency replacements for other selsyns in the set. In many cases there are two selsyns to transmit the same element of data. They are designated as fine and coarse selsyns in accordance with the gear ratios which drive them. The coarse selsyn is driven by a gear ratio such that the selsyn turns only a small amount for a given change in the data being transmitted, while the fine selsyn is driven by a gear ratio such that it turns a large amount for the same change of data. This increases the accuracy of the transmitted data since the two selsyns work together like the hands of a watch, with the coarse selsyn corresponding to the hour hand and the fine selsyn to the minute hand. The four receiving selsyns of the antenna position indicator unit are all of the coarse ratio type, although they are not identified by that name. The complete list of data selsyns with their ratios is given below:

a. Altitude transmitting selsyn—
10,000 yds per rev.

b. Fine range transmitting selsyn—
2,000 yds per rev.

c. Coarse range transmitting selsyn—
50,000 yds per rev.

d. Fine elevation transmitting selsyn—
400 mils per rev.

e. Coarse elevation transmitting selsyn—
6,400 mils per rev.

f. Fine azimuth transmitting selsyn—
400 mils per rev.

g. Coarse azimuth transmitting selsyn—
6,400 mils per rev.

h. Local elevation receiving selsyn—
6,400 mils per rev.

i. Local azimuth receiving selsyn—
6,400 mils per rev.

j. Remote elevation receiving selsyn—
1,800 mils per rev.

k. Remote azimuth receiving selsyn—
6,400 mils per rev.

181. ANTENNA POSITION INDICATOR UNIT.

The function of this unit in the data transmission system is to indicate to Radio Set SCR-784 operators the position of the antenna and the gun director telescopes. This unit contains four receiving selsyns which are geared to concentric pointers in the two indicator dials on the panel.

a. The local azimuth receiving selsyn is geared to the local index of the azimuth dial with a 1 to 1 ratio. Its stator is connected to the coarse azimuth transmitting selsyn in the pedestal. Consequently, the local index of the azimuth dial indicates the azimuth of the antenna. The remote azimuth receiving selsyn is geared to the remote azimuth index of the dial with a 1 to 1 ratio. This index indicates the azimuth of the director telescope.

b. The local elevation receiving selsyn is geared to the local elevation index with a 1 to 1 ratio, to indicate the elevation of the antenna. The 64 to 18 speed remote elevation receiving selsyn is geared to the remote elevation index and indicates the elevation angle of the director telescopes. Transformer T1201 supplies 6.3 volts ac for the dial lamps and for the director signal circuit. There are three lamps behind each dial and these lamps are on whenever the main power switch is turned to the ON position.

182. ORIENTATION OF SELSYNS.

a. General.

(*1*) If the various selsyns are to transmit their data correctly, they must be adjusted so that the receiving mechanism is at its zero position when the transmitting mechanism is at zero. In order to orient the selsyns, cooperation with the director personnel is required since the receiving selsyns are located in the director.

(*2*) The receiving selsyns can be made to indicate the direction the antenna is pointing by either moving mechanically the rotor of the

transmitting selsyns with respect to the antenna or rotating the stator of the transmitting selsyn. The rotation of the stator changes the relative position in space of the field set up by the stator windings and hence the position that the rotor assumes when excited. The stator is rotated until the index points to the correct value of azimuth or elevation on the dial.

b. Azimuth. The azimuth selsyns and azimuth potentiometer in the pedestal base are all moved in synchronism by the azimuth orientation handle and clamped by the azimuth orientation locking handle (fig. 356). In addition, a particular selsyn may be moved individually by loosening its clamps and turning its stator by hand. When properly oriented the following selsyns should indicate the same azimuth:

(*1*) Coarse and fine selsyns at the director.
(*2*) Antenna position indicator unit.
(*3*) PPI sweep.
(*4*) Voltage data at the director.

c. Elevation. The elevation selsyns and elevation potentiometer in the pedestal are all moved in unison by the elevation orienting adjusting arm. This arm is moved and locked by a setscrew and locknut (fig. 371). In addition, the selsyns may be adjusted individually by loosening the clamps and turning the stators by hand. For a rough alignment without a director, a specially milled leveling surface is provided on the reflector mounting. A gunner's quadrant or spirit level can be used on this surface to put the reflector axis in a horizontal position. When properly oriented in elevation, the following selsyns should indicate the same elevation:

(*1*) Coarse and fine selsyns at the director.
(*2*) Antenna position indicator unit.
(*3*) Voltage data at the director.

d. Altitude. The altitude selsyn is provided with a screwdriver adjustment (fig. 247) so that it may be oriented to have the receiving selsyn indicate zero when the altitude dial reads zero.

e. Antenna Position Indicator Unit. The selsyns are oriented so that they show the position of the SCR-784 with respect to the director. These selsyns are provided with a clamp type of mounting so that the stators may be rotated by hand as required. The rotation of the stator is needed usually only on the initial orientation with a new director, but it should be checked at each orientation. The remote elevation receiving selsyn is provided with a 64 to 18 ratio of gears between the selsyn rotor and the index. This makes it possible for the index to lock in at one correct position or one of two incorrect positions when the excitation power is removed and reapplied between various operating periods. To prevent this error, check with the director to be sure the telescope elevation is approximately the same as indicated by the index before applying the excitation power. If by some chance the index becomes locked in the wrong position by application of excitation power without this precaution being taken, the remote selsyn in the SCR-784 will have to be reoriented by the procedure of removing excitation power, rotating the index by hand to the correct position (this involves the removal of the glass in front of the index) and then reapplying the excitation power.

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SECTION III

POTENTIOMETER DATA SYSTEM

183. INTRODUCTION.

There are two ways of tracking a target with the SCR-784 and the M9 or M10 directors. The most common is, probably, radar tracking with the radar set feeding all position data to the computer. The other method is optical tracking with the antenna position controlled by the optical tracker, and the radar set feeding range data only to the computer. Switch S1907 on the switch and data panel of the SCR-784 must be set to the SLANT RANGE position for use with this type of director. The connections that are made in this position are shown in figure 223.

184. VOLTAGE DATA.

a. The data potentiometers transmit data by means of voltages which are proportional to the slant range, horizontal range, altitude, north-south range, and east-west range. The slant range is the basic information which is then expressed in terms of the horizontal range and altitude by the elevation potentiometer. Then the horizontal range is converted into north-south and east-west components by the azimuth potentiometer. These various components of the target position are illustrated in figure 219. This method of data transmission is all in distances or ranges and no angles are involved in the final data. In the SCR-784 the maximum range that can be measured this way is 28,000 yards; this is well beyond the maximum range of the guns. As has been explained previously, the SCR-784 is capable of finding targets at longer ranges, and the limit of 28,000 yards applies only to the voltage data transmission.

b. The maximum range of 28,000 yards is represented by –350 volts and hence all other ranges will be represented by proportional voltages. For example, 14,000 yards is represented by –175 volts, 7,000 yards by –87.5 volts, and 4,000 yards by –50 volts.

(*1*) Figure 224 is an elevation diagram which illustrates the action of the elevation potentiometer in converting the slant range into altitude and horizontal range. The range potentiometer supplies the basic slant range

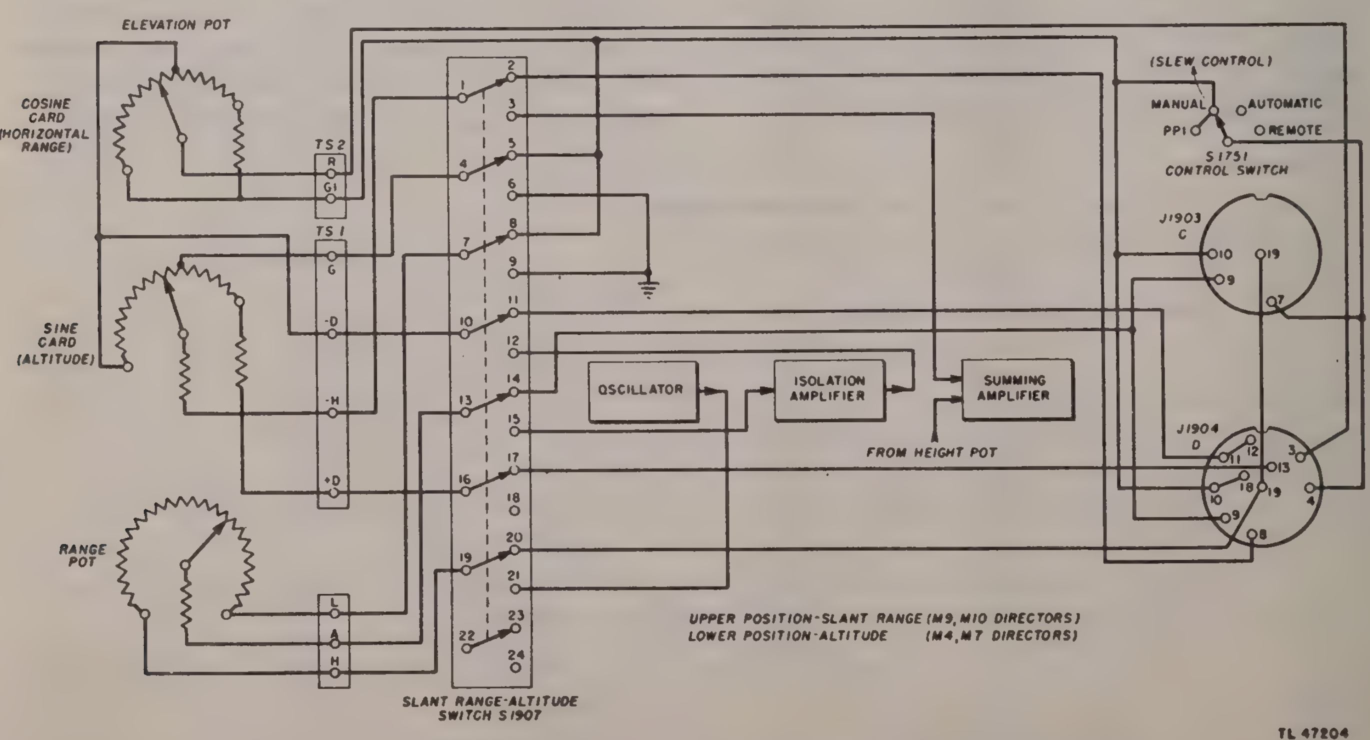

Figure 223. Slant range-altitude switch, simplified schematic diagram.

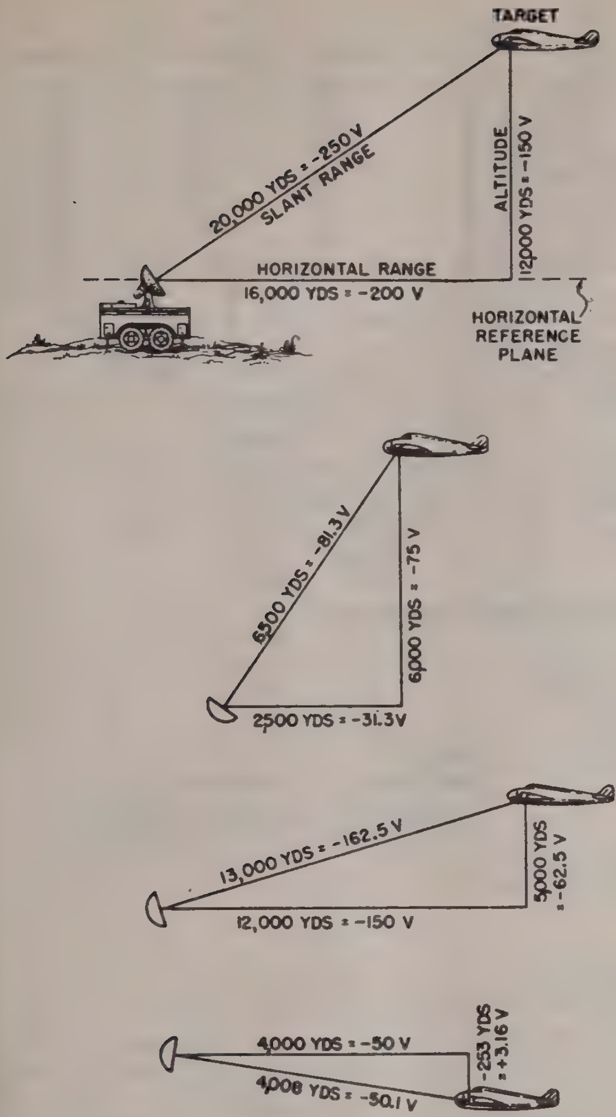

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Figure 224. Elevation potentiometer, voltage data.

information and the elevation potentiometer converts it into the proper proportional voltages. Notice that all the voltages are negative with respect to ground except altitude below the horizontal which is positive. The horizontal range is always negative because the elevation picture does not require that the azimuth angle be expressed as positive and negative components of horizontal range.

(*2*) Figure 225 shows the azimuth picture and illustrates the manner in which voltages are used to represent the east-west range and the north-south range. The voltages are produced by the azimuth potentiometer which is fed with both + and − voltages proportional to the horizontal range of the target. The potentiometer output is then the X_0 (east-west range) and Y_0 (north-south range) which may be either + or − depending on the quadrant or quarter of the picture in which the target is located.

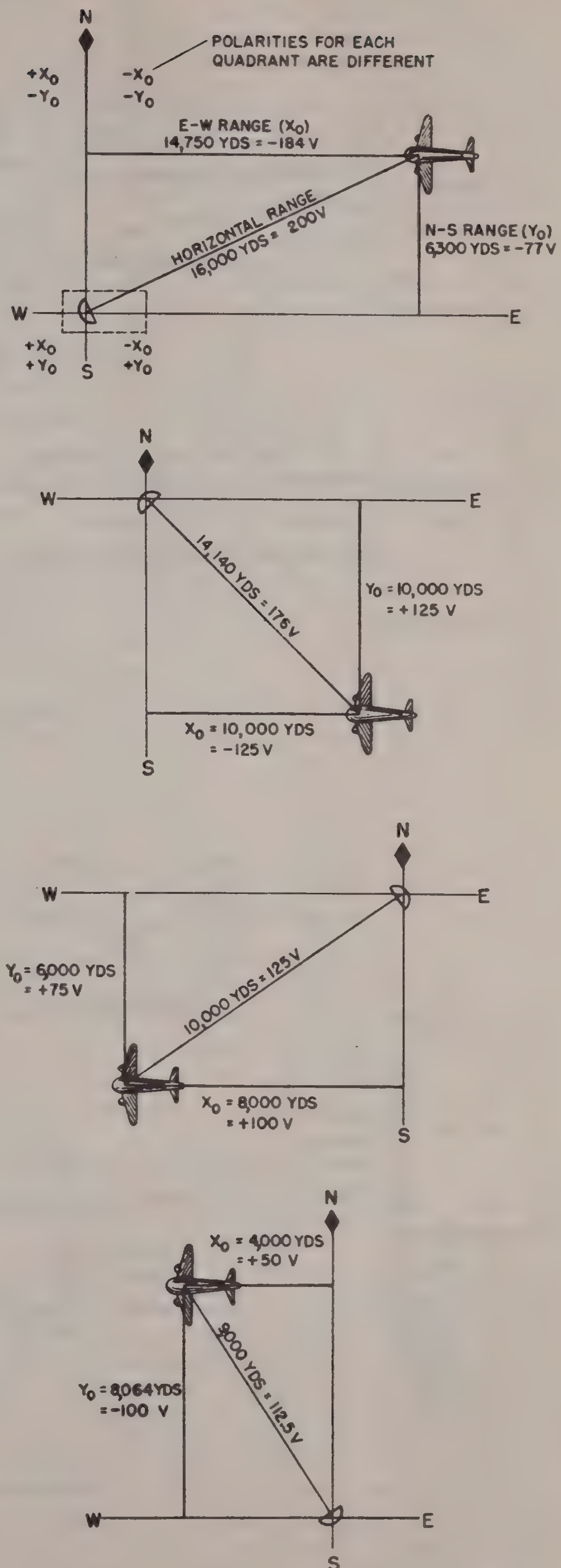

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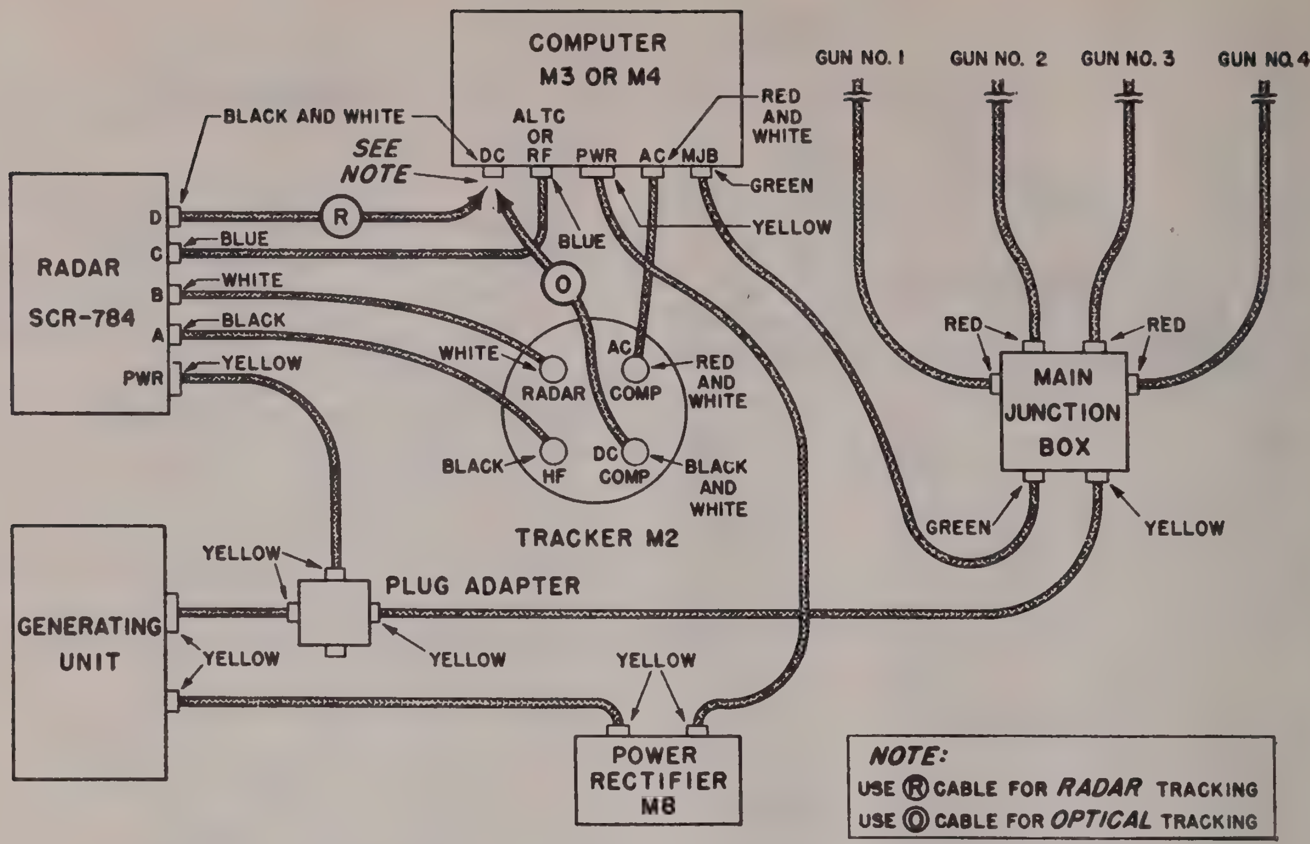
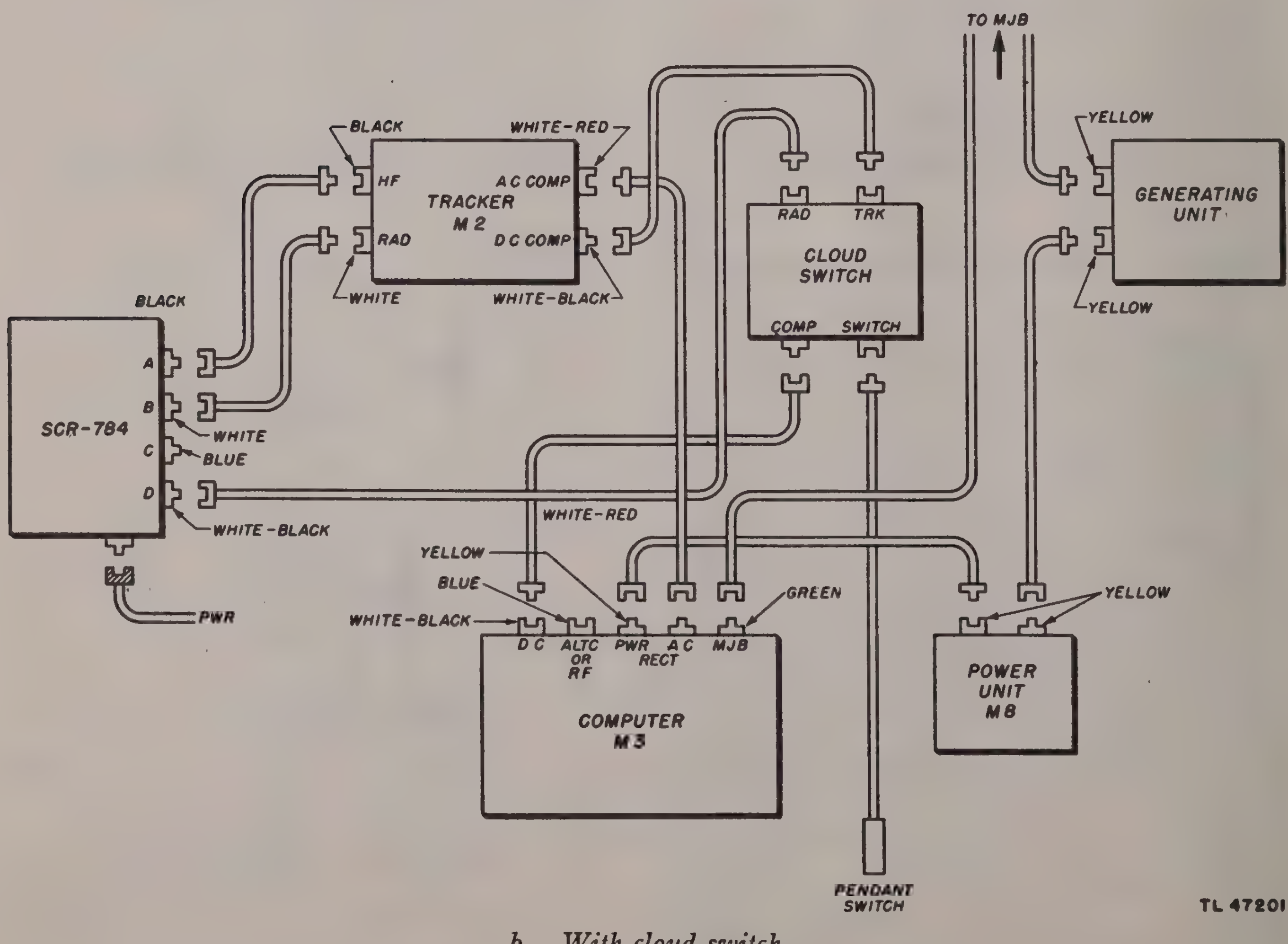
Figure 225. Azimuth potentiometer, voltage data.



a. Without cloud switch.



b. With cloud switch.

Figure 226. Gun directors M9 or M10, cable connections.

Figure 225 shows the polarity of X_0 and Y_0 for each of these quadrants. These polarities are carried through in the voltages of parts A, B, C, and D of the figure which show examples of targets at different ranges and in each of the quadrants.

185. RADAR TRACKING WITH M9 OR M10 DIRECTORS.

a. For this type of tracking, the cables to the director are connected as shown in figure 226*a*. Note that this type of director has two parts to which the SCR-784 is connected, the computer M3 or M4 and the tracker M2. The voltage data is transmitted to the computer and selsyn data is transmitted to the tracker.

b. The connections for radar tracking with the M9 are indicated in block diagram form in figure 227. This diagram shows only those parts which are connected for this particular application. The diagram is simplified by omitting the terminal blocks, switches, and slip rings which are in the actual circuit. This diagram shows the flow of the data to and from the director.

c. To consider the voltage data flow, the origin is a –350-volt supply in the director which is applied to the range potentiometer of the SCR-784. A voltage proportional to the range of the target goes back to the director. The slant range voltage is developed by the director into positive and negative voltages each equal in magnitude to the slant range voltage and these are sent back to the elevation potentiometer of the set. The elevation potentiometer then supplies voltages proportional to the horizontal range and altitude of the target (fig. 224). The altitude is used by the director in its computing circuits and the horizontal range is developed into equal positive and negative voltages that are again fed back to the azimuth potentiometer of the SCR-784. This potentiometer then supplies X_0 and Y_0 components of range that are used by the computing circuits of the director. The CONTROL SWITCH has contacts that short out certain circuits in the director when the set is operating on MANUAL and PPI SCAN (fig. 223).

d. The selsyn data is supplied to the tracker to indicate the direction in which the SCR-784 antenna is pointing. This allows the tracker operators to position the telescopes accurately on the target for observation of fire or verification of the correct target. This data is supplied through cables A and B and includes the coarse and fine azimuth data and the coarse and fine elevation data. These cables also carry the circuits which show the position of the director telescopes on the dials of the antenna position indicator unit. The selsyn excitation voltage and an indicator light circuit connected to the director signal switch are also included in the cables A and B (fig. 227).

186. OPTICAL TRACKING WITH M9 OR M10 DIRECTORS.

This type of operation requires a change of connections from the radar tracking condition. Cable D is removed from the computer and a cable from the tracker substituted (fig. 226*a*). The cable connections for optical tracking with the cloud switch is shown in figure 226*b*. The connections for the data flow are then as shown in figure 228. The only voltage data supplied by the SCR-784 is the slant range. The functions served by the elevation and azimuth potentiometers are now performed by similar potentiometers in the tracker. The selsyn data on the SCR-784 antenna position is still transmitted to the tracker. The tracker transmitting selsyns now feed the azimuth selsyn transformer in the antenna mount as shown, in order to control the positioning of the SCR-784 antenna as described in chapter 7. In this type of operation the SCR-784 operators perform the range tracking or automatic range tracking can be used, but the tracking in azimuth and elevation is done by the director operators. Slant range is transmitted to the computer from the range potentiometer.

187. RANGE POTENTIOMETER.

a. General. Range potentiometer R903 is part of the range indicator unit. In this unit a train of gears rotates the potentiometer contact arm and brush in accordance with the measurement of slant range as indicated on the dial of the range scopes (fig. 229). As shown in figures 229 and 230, the contact brush when rotated rides on the edge of the potentiometer card (the form on which the resistance wire is wound) and contacts the potentiometer resistance winding. In operation, an input voltage is applied across the potentiometer winding and a variable output voltage is obtained from the potentiometer brush. This output is used as a measure of the slant range.

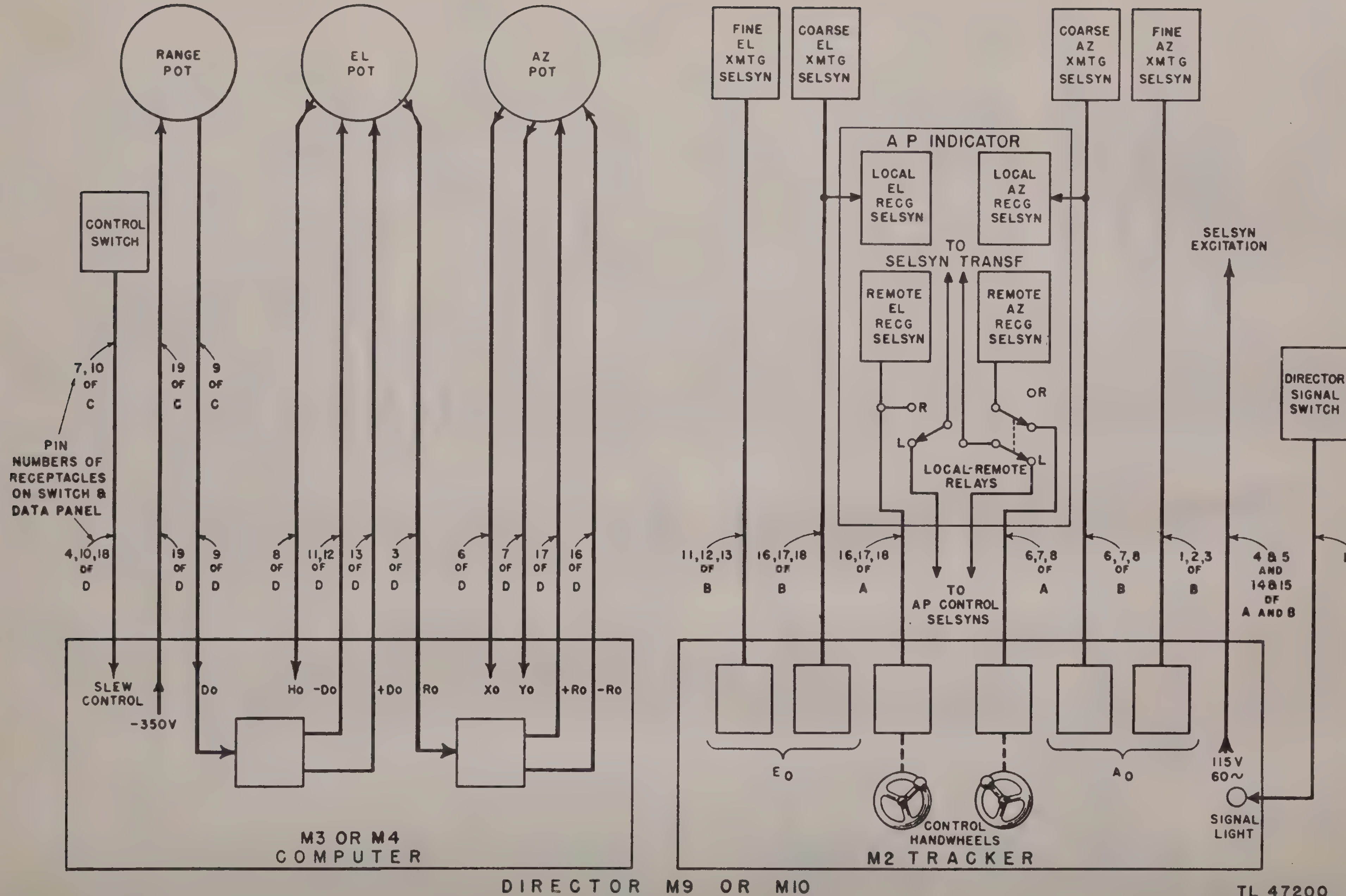


Figure 227. Radar tracking with M9 or M10 gun directors, block diagram.

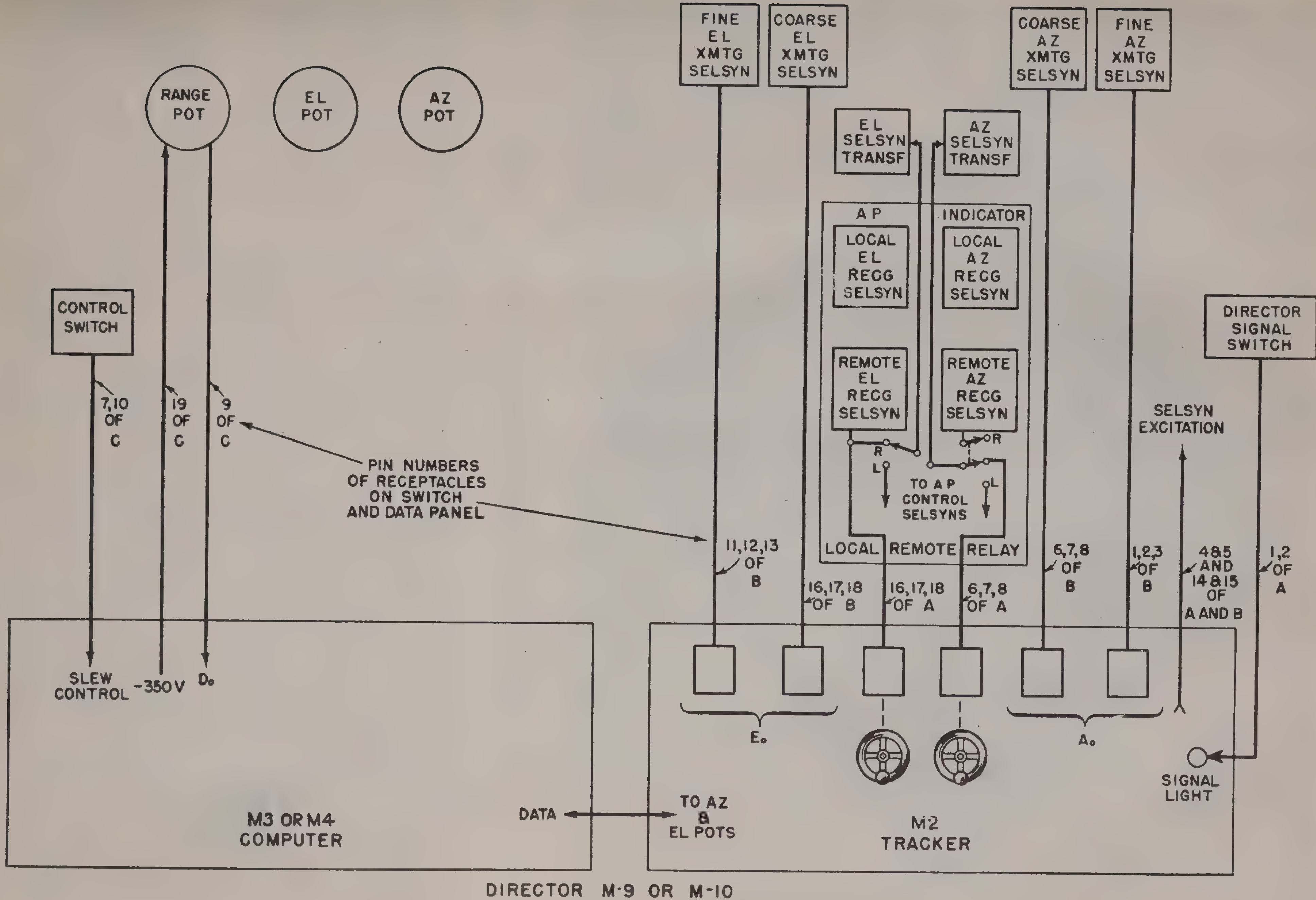


Figure 228. Optical tracking with M9 or M10 gun directors, block diagram.

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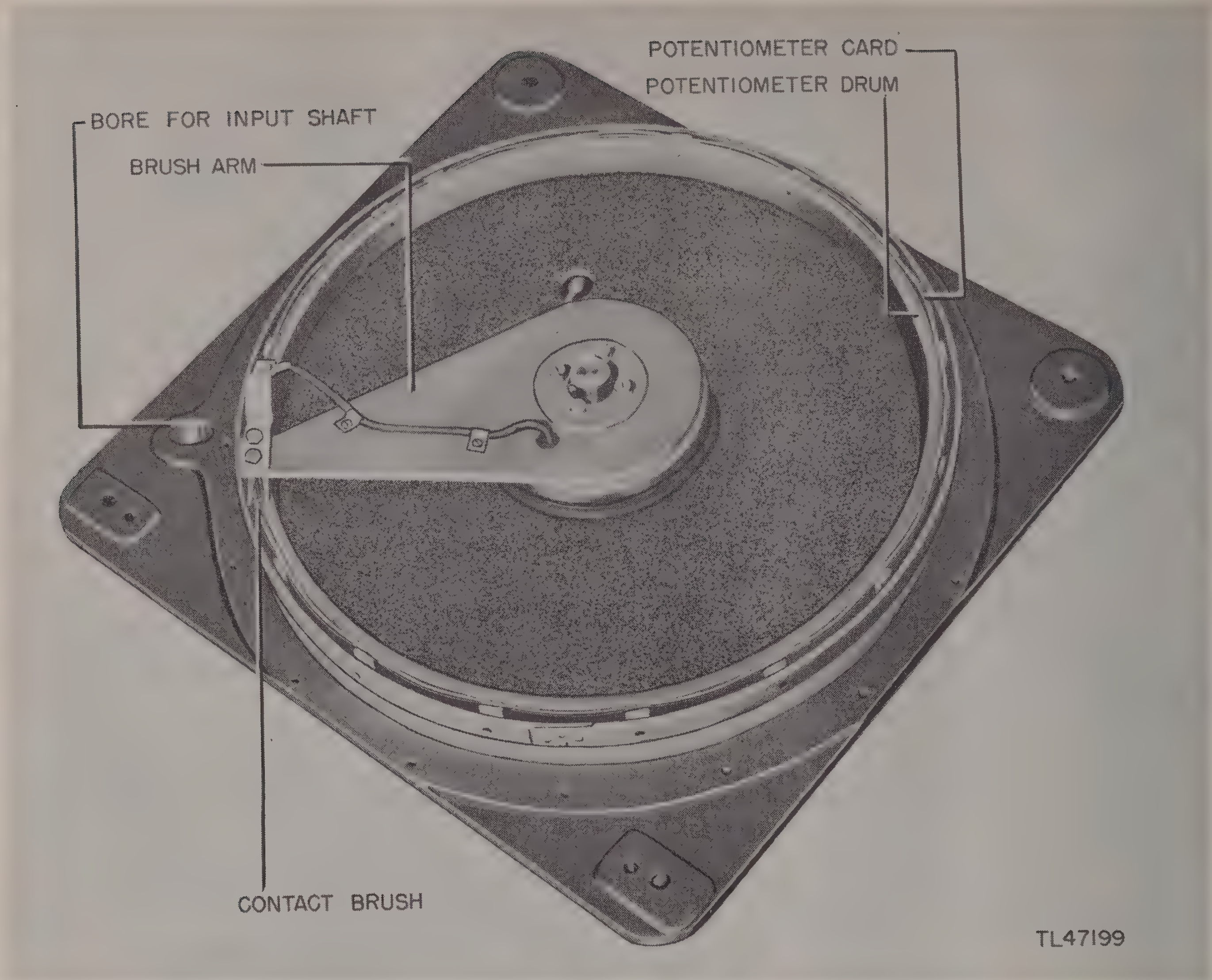

Figure 229. Range potentiometer, phantom view.

b. Mechanical. The potentiometer drive shaft rotates one revolution for every 4,000 yards of range, and the maximum operating range of the potentiometer is 28,000 yards. The drive shaft and associated pinion, however, are not part of the range potentiometer. The drive pinion fits inside the potentiometer housing and meshes with an idler gear which drives a large gear fastened to the potentiometer brush arm shaft. The over-all ratio of these gears is 7½ to 1. The idler gear can be shifted a small amount to eliminate backlash. The large gear on the center shaft drives the potentiometer brush arm shaft through a spring linkage which allows the potentiometer input drive to continue to an amount equivalent to 40,000 yards (12,000 yards beyond the operating range of the potentiometer). The potentiometer brush arm shaft rotates through 28/30 of a revolution in covering the 28,000-yard operating range. This fraction is computed on the basis that one complete revolution is 30,000 yards. When the input drive travels below zero, a buffer spring is provided to prevent the potentiometer brush arm shaft from coming to a sudden stop. The brush arm shaft may rotate below zero range to a maximum of –250 yards. During this travel, however, the output voltage is zero.

c. Electrical. Except for the design precautions which are taken to insure a high degree of precision in potentiometer R903, this unit is a comparatively simple variable resistance voltage-dividing network from an electrical point of view. As shown in figure 230, the potentiometer circuit consists of the 20,000-ohm potentiometer winding, the contact brush, and the 10,000-ohm protective resistor R1. In operation

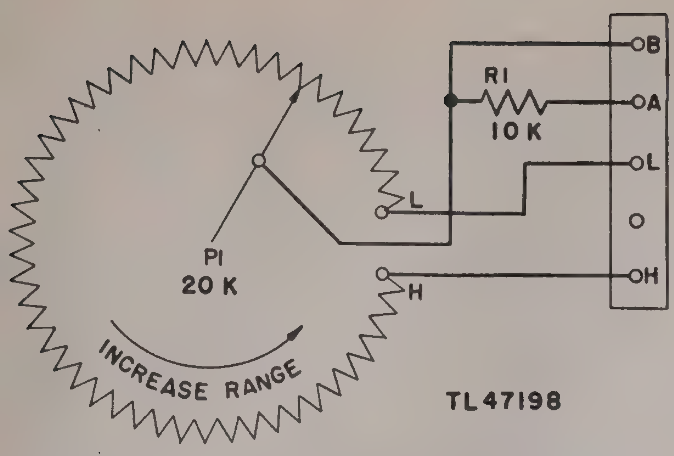

Figure 230. Range potentiometer, schematic diagram.

the input voltage applied across terminals L and H produces an output voltage across terminals L and A. The ratio of input voltage to output voltage is dependent upon the point of contact of the contact brush on the potentiometer winding. The potentiometer winding has been designed for use with an output load of 250,000 ohms. Of this load resistance 10,000 ohms (resistor R1) is located inside the potentiometer for protection in case of a short circuit in the load. The net load is therefore 240,000 ohms and should be connected across the output terminals L and A for proper operation.

188. ELEVATION POTENTIOMETER.

a. General. Elevation potentiometer R2051 sends elevation angle data (obtained from the elevating mechanism of Pedestal MP-61-B) to either the altitude converter or to the M9 or similar type gun director. This potentiometer forms part of the pedestal. In operation the potentiometer drive shaft is rotated through a train of 3 to 1 ratio gears. As shown in figure 234, the drive shaft rotates a single potentiometer arm with two contact brushes. Each of the brushes contacts a separate potentiometer resistance winding to produce output voltages proportional to the altitude and horizontal range, as illustrated in figure 233.

b. Mechanical. As shown in figure 234 the elevation potentiometer is two potentiometers in one. There are two brushes, each contacting a potentiometer card. The two cards are concentrically mounted and oriented with respect to each other so that the contact brushes may be mounted on essentially the same radial line.

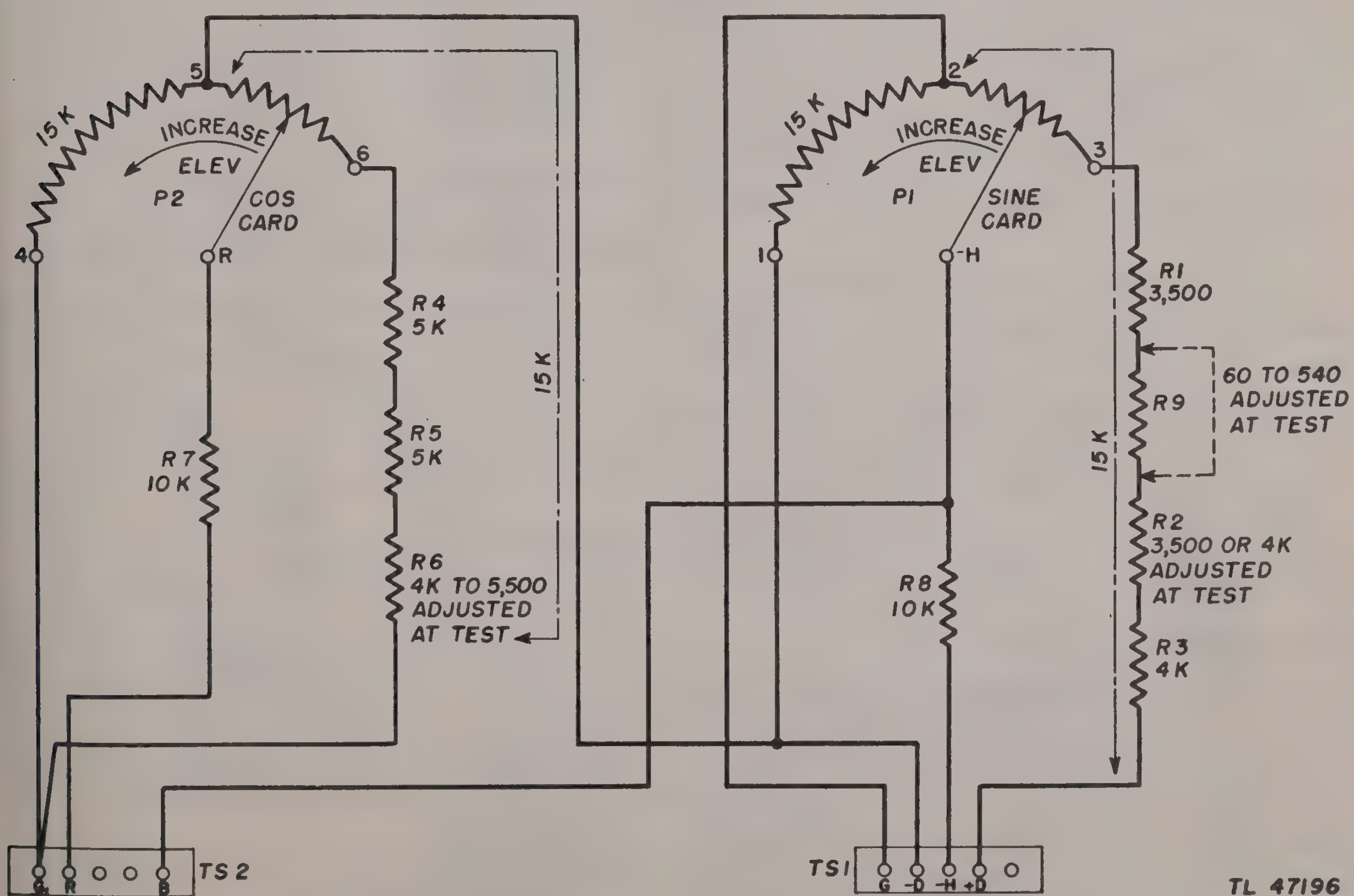

Figure 231. Elevation potentiometer, schematic diagram.

There is no internal gearing in the potentiometer; however, the associated 3 to 1 gear train is required because it permits a 3 to 1 increase in angular rotation of the potentiometer and a correspondingly greater accuracy of output data. The elongated mounting holes of this potentiometer facilitate orienting the potentiometer output data with respect to the elevation angle setting. No means of orientation are provided inside the potentiometer itself.

c. Electrical.

(*1*) The electrical functioning of the elevation potentiometer is explained below with the aid of the schematic diagram (fig. 231) and the functional diagram (fig. 233). The functional diagrams of figure 233 indicates the input and output voltages by the appropriate notes. The potentiometer winding covers slightly more than a quarter of elevation (from –200 mils to the vertical position or +1,600 mils). This coverage of the winding requires an effective resistance of a half circle, so that the part not on the potentiometer card is made up by what are called "pad-out" resistors (R4, R5, R6 for the horizontal range card and R1, R2, R3, R9 for the altitude card). The potentiometer card windings are designed for accurate results when working with 250,000-ohm loads. For the purpose of protection in the case of an accidental short circuit, 10,000 ohms of these output loads are included inside the potentiometer in resistors R7 and R8.

(*2*) The voltages produced by the elevation potentiometer are measures of the horizontal range and altitude of the target. In figure 224 a number of examples are shown for various target positions. The fact that these two outputs depend upon the elevation angle makes it possible to obtain them by potentiometer windings which are specially designed. The sine of the elevation angle gives the altitude and the cosine gives the horizontal range.

(*3*) Figure 233 applies to the use of the elevation potentiometer for the voltages required by the M9 or M10 directors. A negative voltage proportional to slant range (fig. 233 cosine section) is fed into the horizontal range card and the desired voltage appears in the output as a negative voltage with respect to ground. To obtain voltages which indicate whether the target is above or below the horizontal reference, it is necessary to have both negative and positive input voltages as shown. The resulting altitude output is then either a positive or negative voltage depending on the position of the potentiometer arm.

(*4*) For use with the altitude conversion system which will be explained fully later, the altitude card is used with an applied a-c voltage of 250 cycles per second. In this case altitudes below the horizontal reference cannot be obtained and consequently only the portion of the card from terminals 2 to 1 is used. The horizontal range card is not used in connection with the altitude conversion system.

189. AZIMUTH POTENTIOMETER.

a. General. The function of azimuth potentiometer R2001 is to send azimuth angle data obtained from the pedestal to an M9 or similar type gun director. This potentiometer forms part of the pedestal. In operation the potentiometer drive shaft is rotated through a pair of 1 to 1 ratio gears by the azimuth rotation of the pedestal. As shown in figure 236, two brushes contact the potentiometer winding at points displaced by 90 degrees. When the input terminals are connected to equal positive and negative voltages, two precise output voltages are obtained which give the north-south and east-west components of range to the target.

b. Mechanical. As shown in figure 236, the potentiometer has a double contact arm and a single continuous winding. The potentiometer

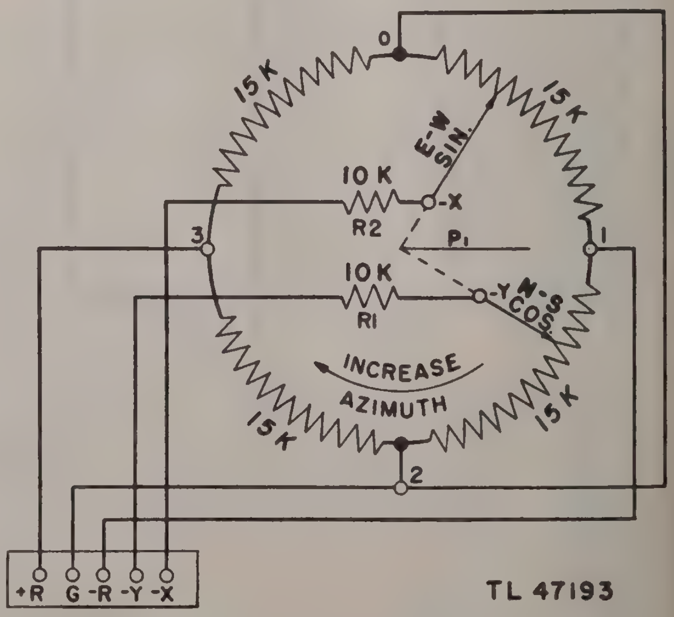

Figure 232. Azimuth potentiometer, schematic diagram.

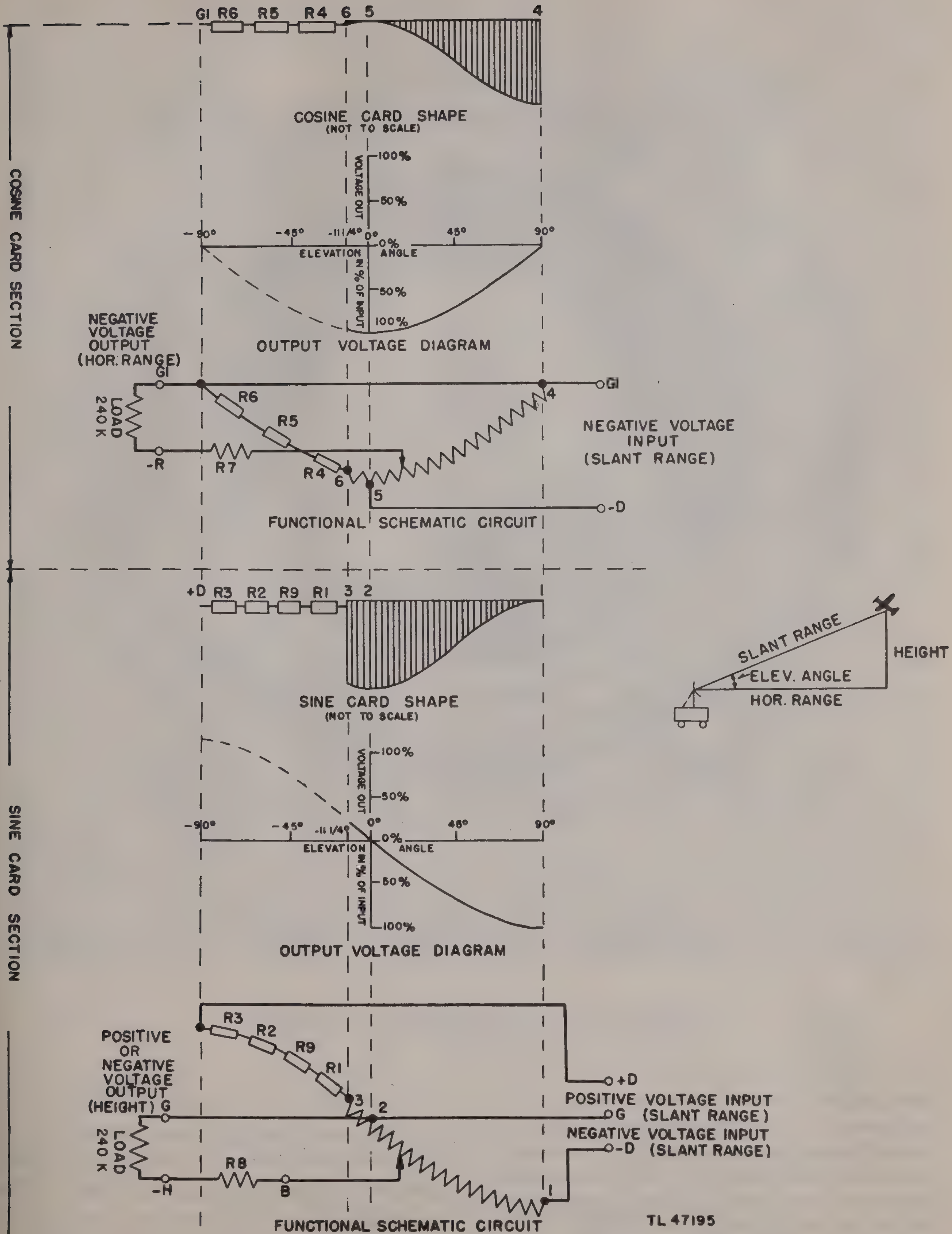

Figure 233. Elevation potentiometer, functional diagram.

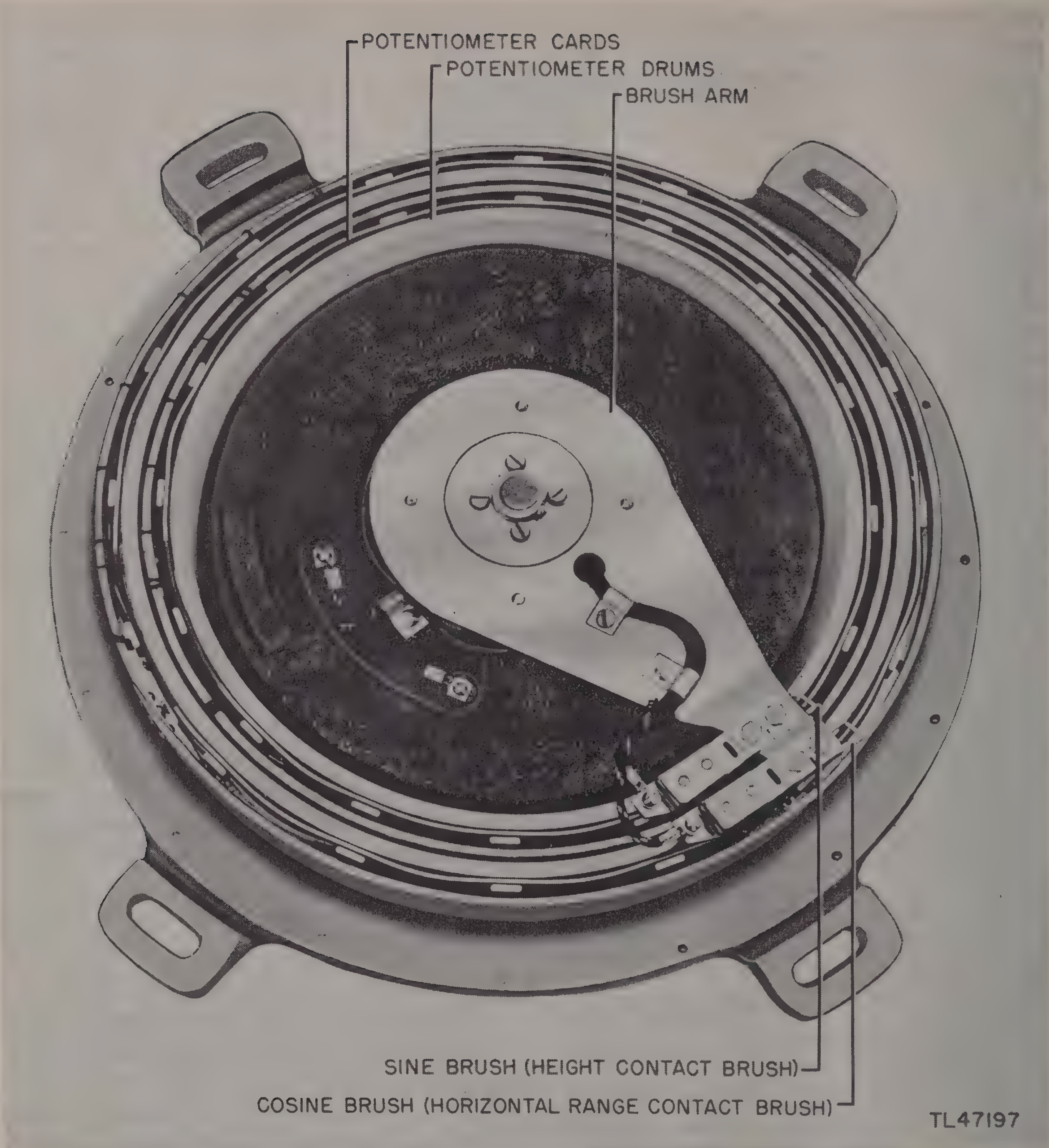

Figure 234. Elevation potentiometer, bottom view.

shaft is continuously rotatable and connections are made to the contact brushes through slip rings. There is no internal gearing in this potentiometer and the associated 1 to 1 ratio gears do not form part of the azimuth potentiometer. No means of adjusting the orientation of the potentiometer with respect to the pedestal are provided within the potentiometer itself.

c. Electrical. The electrical functioning of the azimuth potentiometer is explained below with the aid of the schematic diagram (fig. 232), and the functional diagram (fig. 235). This potentiometer has one continuous winding with four taps for voltage application and two slider contacts. The azimuth potentiometer is also

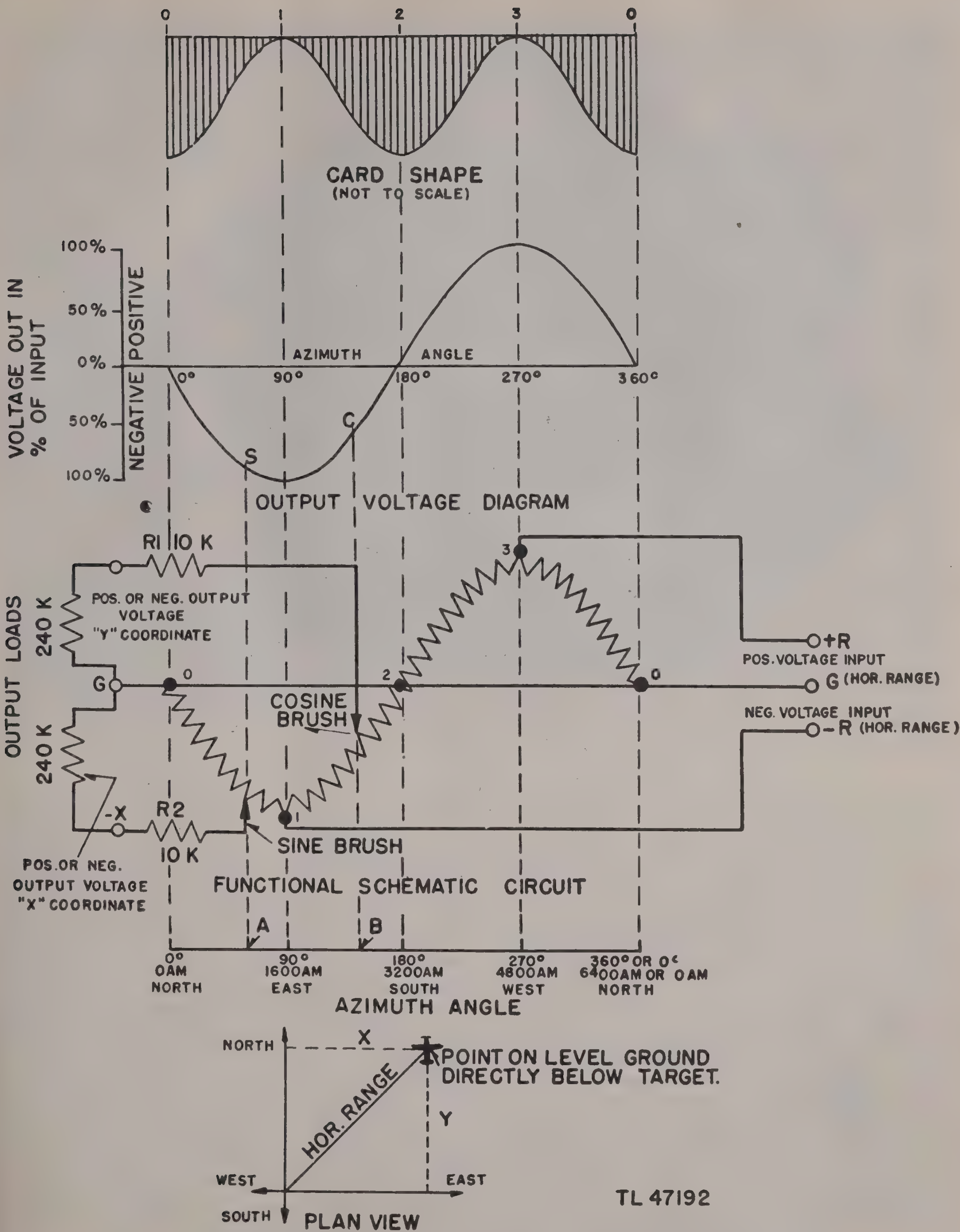

Figure 235. Azimuth potentiometer, functional diagram.

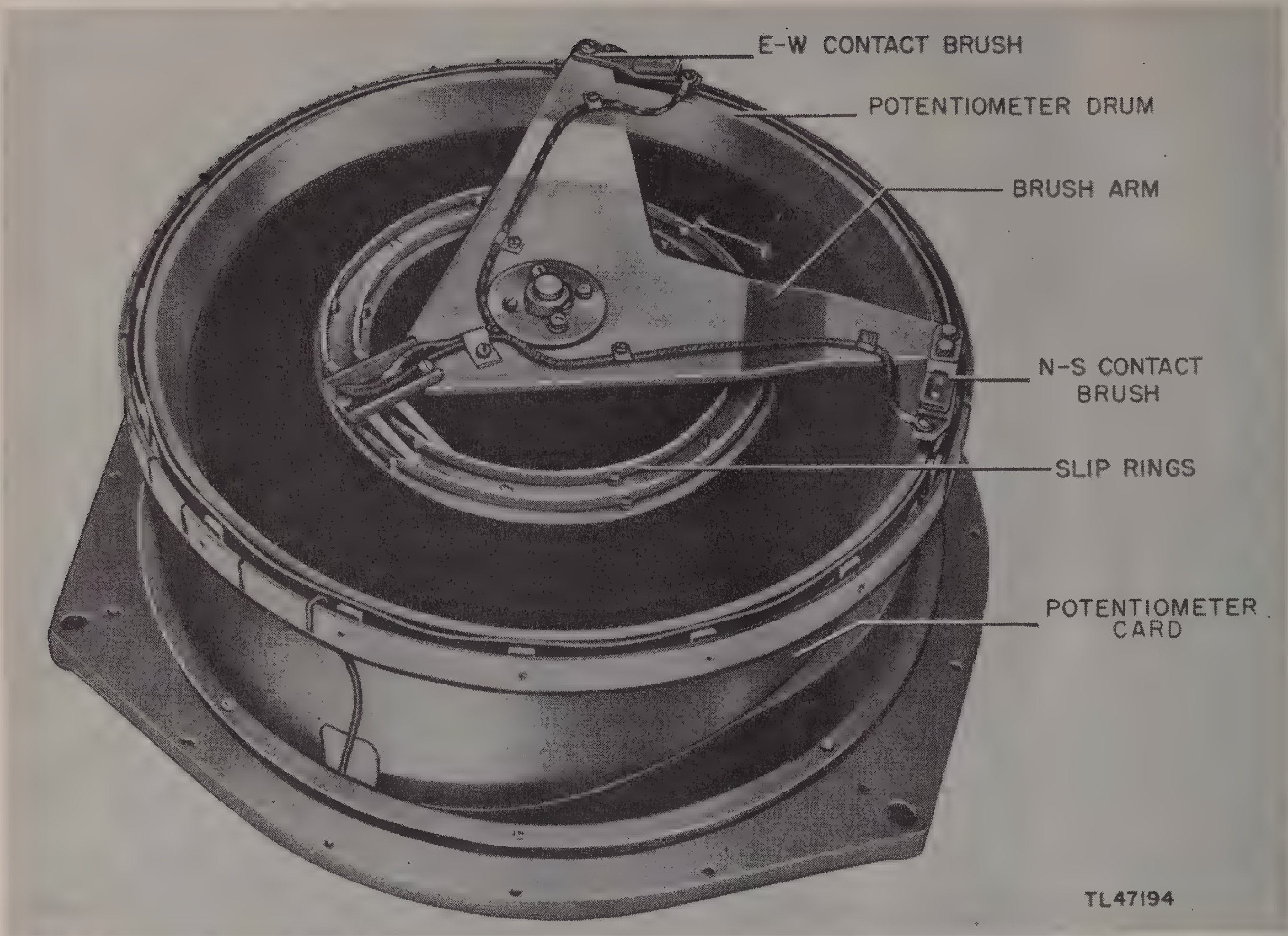

Figure 236. Azimuth potentiometer, bottom view.

designed for 250,000-ohm loads. A small part of each output load is included in the potentiometer to protect the windings against overload; these are the resistors R1 and R2. The voltages applied to the potentiometer are equal positive and negative voltages which have a value corresponding to the horizontal range of the target. The winding of the potentiometer is designed so that the output voltages are the north-south and east-west ranges to the target, when the set is properly oriented. These output voltages were described in connection with figure 225. The winding resistance varies as the sine of the azimuth angle and hence the two contacts 90 degrees apart give voltages which are proportional to the sine and cosine of the azimuth angle. As was pointed out in connection with figure 225 the polarities of X_o and Y_o depend upon the quadrant. The reason why this is so may be seen from the functional diagram of figure 235. Notice that the terminals 0 and 2 of the winding are connected and grounded and that the positive voltage is applied to terminal 3 and the negative voltage is applied to terminal 1. These terminals are 90 degrees apart on the potentiometer so that with the two contacts 90 degrees apart the outputs change polarity with the four quadrants as shown on the plan view. For the position of the target shown (northeast) coordinates are negative, but if the target were southeast, for example, both contacts would be moved to the right 90 degrees. The north-south contact would then produce a positive voltage while the east-west contact would still produce a negative voltage.

SECTION IV
ALTITUDE CONVERSION SYSTEM

190. GENERAL DESCRIPTION OF SYSTEM.

The function of the altitude conversion system is to obtain a mechanical motion proportional to the altitude of the target and to transmit this motion by means of a selsyn to the M4 or M7 directors. The components used are the altitude converter, the altitude data unit, the altimeter, the altitude converter power supply, the range potentiometer, and the elevation potentiometer. The components and cabling are shown in figure 237. The altitude is transmitted by rotation of the shaft of the height potentiometer in the altitude data unit, the altitude transmitting selsyn being driven from this same shaft. Switch S1907 on the switch and data panel must be in the ALTITUDE position for operation of the system. The connections may be traced through the switch in figure 223.

191. COMPLETE BLOCK DIAGRAM (fig. 238).

a. A 250-cycle voltage generated in the oscillator section of the altitude converter is used to energize the range potentiometer and the height potentiometer. The output of the range potentiometer is proportional to the slant range as measured by the SCR-784. The range output is then passed through the isolation amplifier V1403 where it is amplified slightly, reversed in polarity, and applied to the input of the elevation potentiometer. The elevation potentiometer has a winding so designed that its output is proportional to the sine of the elevation angle, provided its input voltage remains fixed. This means that as the elevation angle varies, the potentiometer arm is moved to a point on the resistance card where the output voltage represents the sine of the elevation angle. As pointed out above, however, the voltage applied to the elevation potentiometer is not fixed but varies with the slant range. The voltage output of the elevation potentiometer is, therefore, the product of the slant range and the sine of the elevation angle, which is the altitude. This action is the same that has been described in producing voltage data for the M9 director except that a-c voltage is used here.

b. This altitude voltage and a voltage from the height potentiometer in the data unit are both applied to the summing amplifier V1404, V1405, and V1406. These voltages are of opposite polarity because of the inverting action

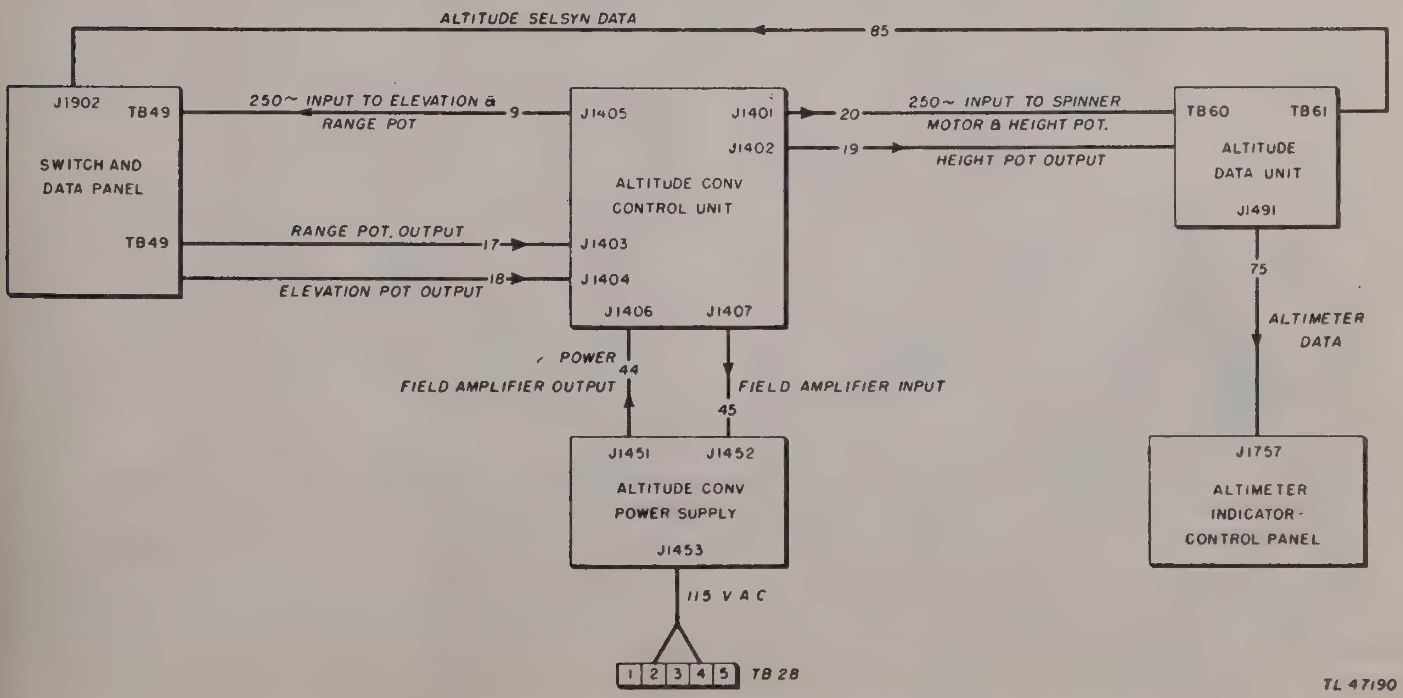

Figure 237. Altitude conversion system, simplified block diagram.

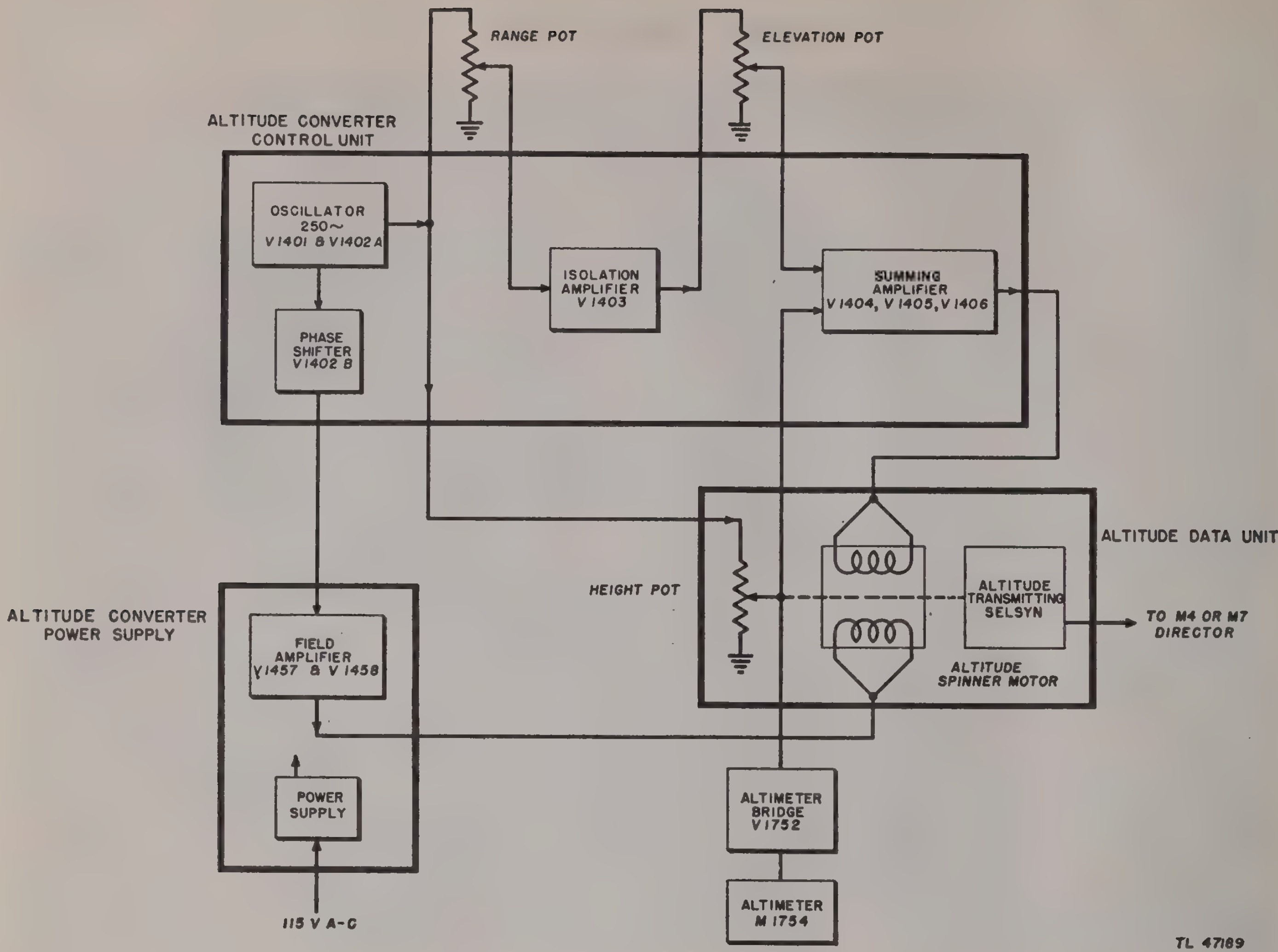

Figure 238. Altitude conversion system, complete block diagram.

of the isolation amplifier. When applied to the summing amplifier, the voltages tend to cancel each other and the difference (algebraic sum) is amplified. The summing amplifier in turn supplies one field of the two-phase altitude spinner motor. The other field of this motor is supplied with the 250-cycle voltage after passing through the phase shifter V1402B (90°) and being amplified by the field amplifier V1457 and V1458 in the altitude converter power supply. The altitude spinner motor is designed so that it drives the data unit height potentiometer in the direction required to balance the two opposing voltages applied to the input of the summing amplifier. When these voltages approach a precise balance, the output of the summing amplifier is reduced to a value which stops the motor. Therefore, the angular position of the shaft of the height potentiometer is a mechanical indication of altitude. By attaching a dial calibrated in yards to the height potentiometer shaft, the height may be obtained directly from the dial reading on the altitude data unit. By using this balancing method, the output of the data unit is made substantially independent of small changes in the oscillator output voltage and depends only on the range potentiometer and elevation potentiometer settings.

c. The voltage on the arm of the height potentiometer is directly proportional to the altitude of the target. By connecting a meter M1754 through a balancing bridge to the arm of the height potentiometer, the altitude of the target can be checked by the operator at the indicator-control panel.

d. The altitude converter power supply is a vacuum tube operated device which receives power from the 115-volt a-c line and converts this power into the proper voltages and currents required by the converter. There are two sections in the power supply. One of these sections is the power supply section and the other is the field amplifier section.

SECTION V
ALTITUDE CONVERTER UNIT

192. INTRODUCTION.

The altitude converter unit consists of a two-stage oscillator, a one-stage phase shifter, a two-stage isolation amplifier, and a three-stage summing amplifier. A front view is shown in figure 240, a top view in figure 239, and the complete schematic in figure 255.

193. OSCILLATOR (fig. 241).

a. The 250-cycle oscillator circuit is a two-stage resistance-capacity type oscillator often called a Wien Bridge oscillator. The output of this oscillator is applied to both the height and range potentiometers and phase shifter. The output of the oscillator stage is amplified by V1402A and then fed back to V1401. The resistor and capacitor arrangement for the grid feedback controls the frequency, as explained in the next paragraph. Resistor R1405 is a control marked OSC OUTPUT and its adjustment will vary the output voltage (normally 25 volts) of the oscillator. V1401 and V1402 are resistance-capacitance coupled in the conventional manner.

b. For an oscillator to operate, two conditions must exist: first, the energy losses of the oscillator must be replaced through the feedback circuit; and second, the phase of the feed-

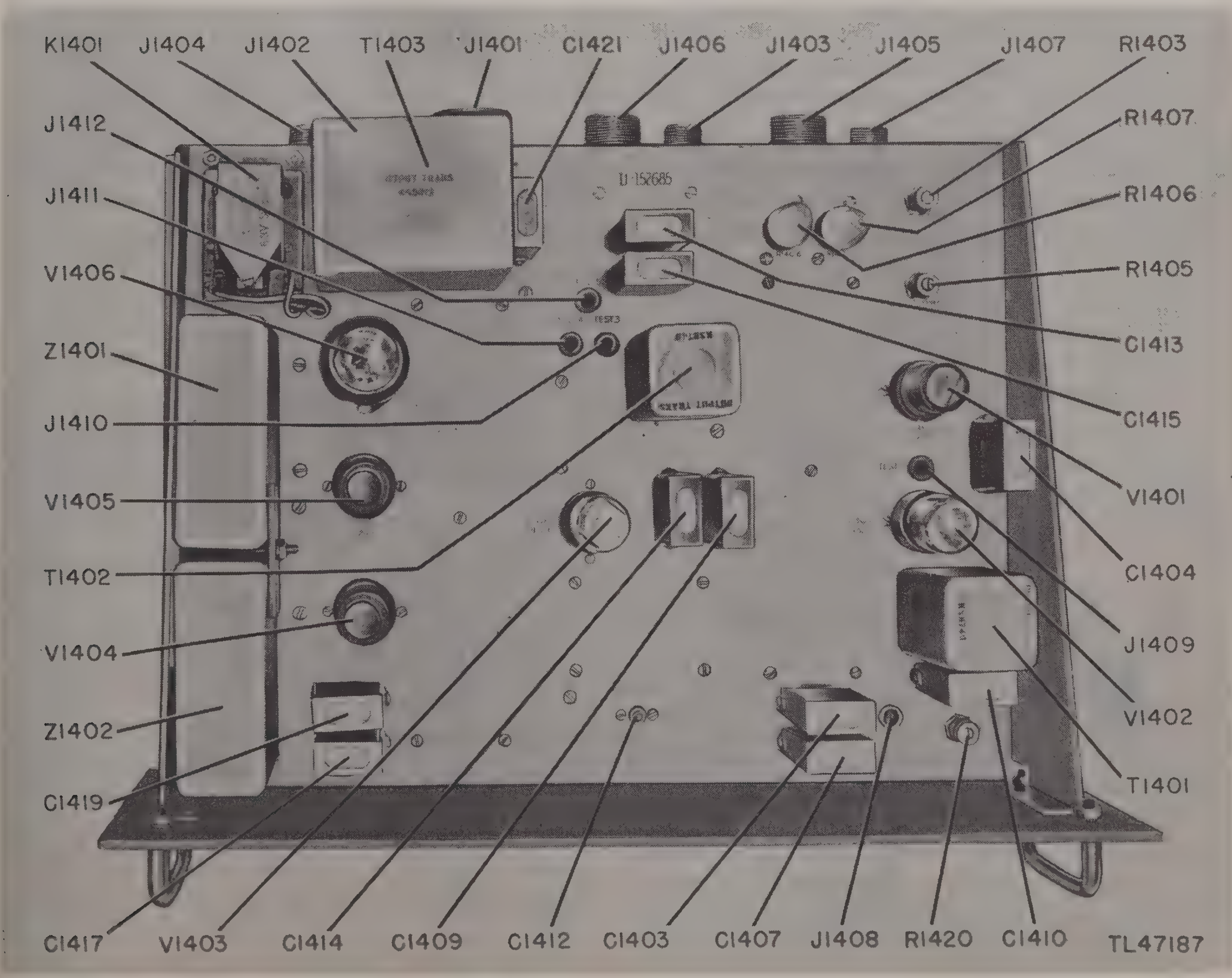

Figure 239. Altitude converter, top view.

Figure 240. Altitude converter, front view.

back must be such that it reinforces the final output when amplified. The feedback line (which passes through TEST 2) puts a-c voltage across the bridge. Because in the right-hand side of the bridge the capacitances are equal and the resistances are approximately equal, the bridge would be balanced if R1405 is equal to the resistance of R1406 and R1407 in series. However, when the oscillator starts, the bulbs R1406 and R1407 are cold and have low resistance. After the oscillator has been on foı awhile the oscillator output flowing through the bridge heats the filaments of the bulbs, bringing the bridge nearer to the balance point. This reduces the amplitude of the a-c voltage between the cathode and grid of V1401, which limits the output of the oscillator. An equilibrium point is reached when the bulbs stop heating and the output at T1401 is about 25 volts. The second condition required is fulfilled by the phase shift in the two tubes. There is a 180-degree phase shift in the first tube, and a 180-degree phase shift in the second tube. If the feedback line is connected to the end of the secondary of T1401 that has the same phase as the output of V1402A, the phase of the feedback line will be the same as the phase of the voltage on the control grid of V1401. The operating frequency is determined in the following manner. Suppose a very low frequency were applied to the bridge, the reactance of C1402 would be high, therefore most of the voltage would appear across C1402 and the voltage at the grid of V1401 would be small. Again suppose a high frequency were applied to the bridge. The reactance of C1401 would be low and the voltage at the grid would again be small. Somewhere between these two extremes there is a frequency which gives maximum voltage at the grid. This is the operating frequency, 250 cycles per second. The COARSE FREQ control R1403 and the FREQ TEST control R1404 control the frequency over a small range. The COARSE FREQ control is factory set and should be adjusted with great care. This adjustment should be attempted only when the FREQ TEST control will not bring the converter into alignment.

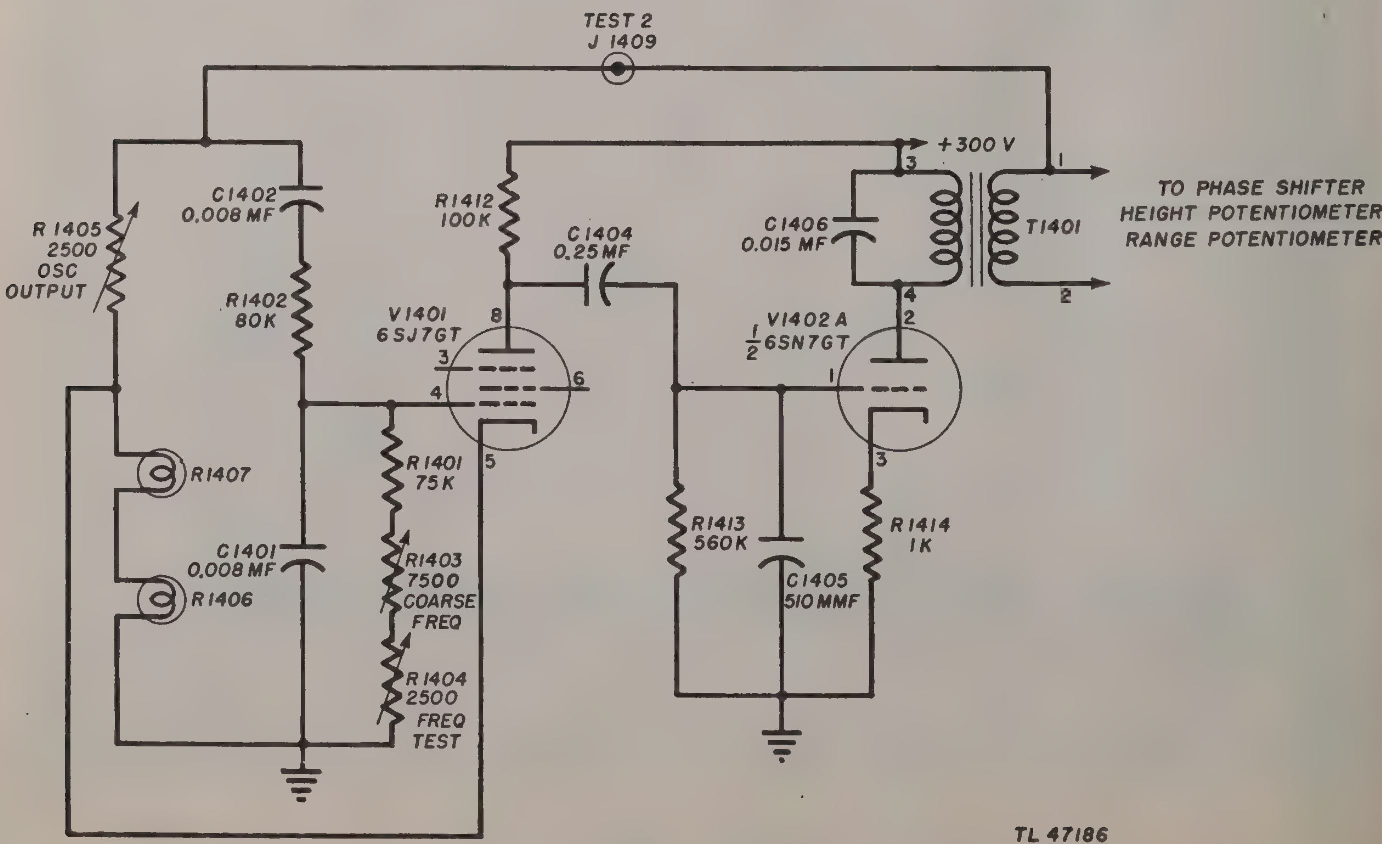

Figure 241. 250-cycle oscillator, simplified schematic diagram.

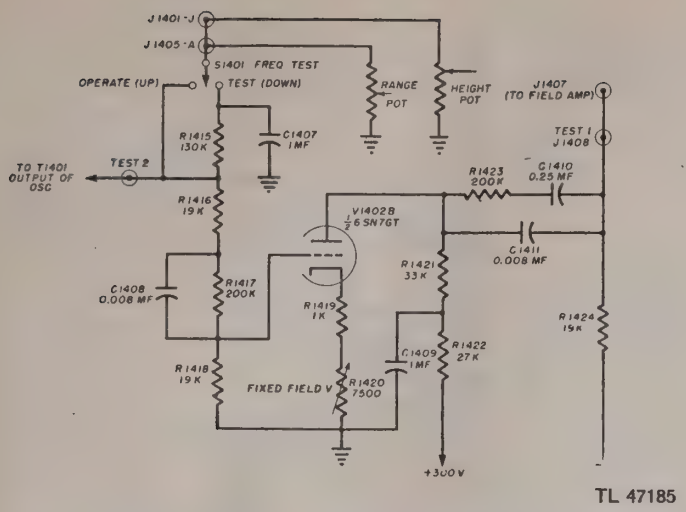

Figure 242. Phase shifter, simplified schematic diagram.

194. PHASE SHIFTER (fig. 242).

a. The 90-degree phase shift circuit is associated with the second half of V1402. This circuit is used to produce a 90-degree phase shift in the voltage used to drive the field amplifier section of the power supply. This is required to obtain the phase difference between the two voltages applied to the altitude spinner motor necessary to make the motor run. This is accomplished by producing a 45-degree phase shift at the input and a 45-degree phase shift at the output of the second half of V1402, as shown by the waveforms in figure 243. In the input circuit a high-pass filter C1408 and R1417, shifts the phase an amount inversely proportional to frequency. At 250 cycles per second the phase shift is 45° leading (fig. 243). The tube, V1402B, reverses the polarity which may be considered a phase shift of 180° either leading or lagging. It is more convenient to show the shift as lagging in the diagram. In the output circuit of the tube, C1411 and R1423 form another high-pass filter which shifts the phase 45°, again in the leading direction. The final result is the algebraic sum of the phase shifts, 90° lagging with reference to the input voltage. This method of securing a 90-degree phase shift introduces some loss in each network, but has the advantage that the phase shift is independent of frequency over a wide range. Bias control R1420 is in the cathode circuit of the phase-shifting stage. This control is marked FIXED FIELD V and is normally set to give an output of 15 volts at TEST 1.

b. Switch S1401 connects network R1415 and C1407 in the circuit for test purposes. The operation of this switch nullifies the effect of the 90-degree phase shift circuit. Network R1415 and C1407 form a low-pass filter circuit shifting the phase of the oscillator output which eventually reaches the other field of the altitude spinner motor. At the operating frequency the reactance of C1407 is low compared to the resistance of R1415; so the resulting phase shift of the voltage across the capacitor is 90 degrees behind the current or the voltage across the circuit. If the circuit is in adjustment the voltage on each field of the altitude motor is in phase and the motor will not run, but if the motor does run under the test procedure, it shows there is some unwanted phase shift in the circuits. This may be corrected by adjusting the 250-cycle frequency slightly. After adjustment the test switch S1401 is returned to the OPERATE position and the phase shift between the motor fields should be 90 degrees.

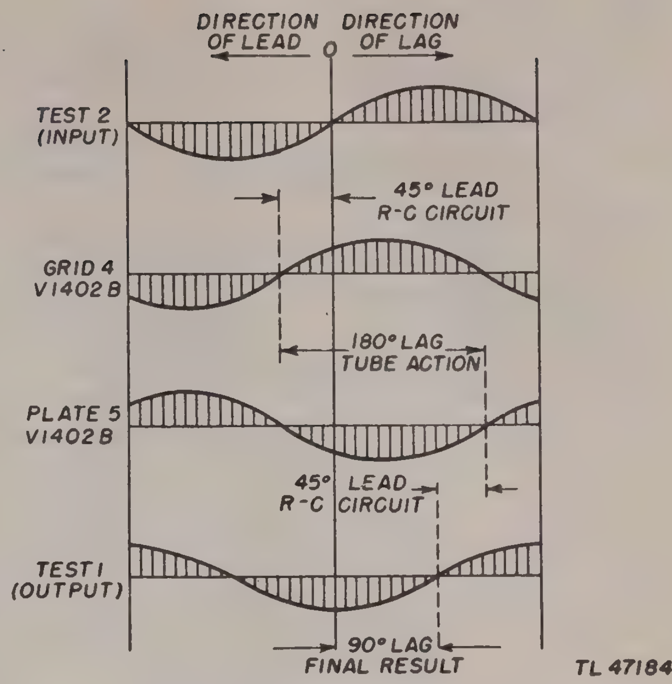

Figure 243. Phase relations in phase shifter.

195. ISOLATION AMPLIFIER (fig. 244).

The isolation amplifier is a highly stabilized negative feedback amplifier having an over-all voltage amplification of only 1.6. It is used to couple the output of the range potentiometer to the elevation potentiometer. It is a two-stage amplifier using the triode halves of a 6SN7GT tube as separate tubes. The essential requirement of this amplifier is that its voltage amplification remains very constant. This is accomplished by introducing initially a large amount of gain and then reducing it almost entirely by means of negative feedback to grid 1 of V1403. The feedback is negative because the phase is

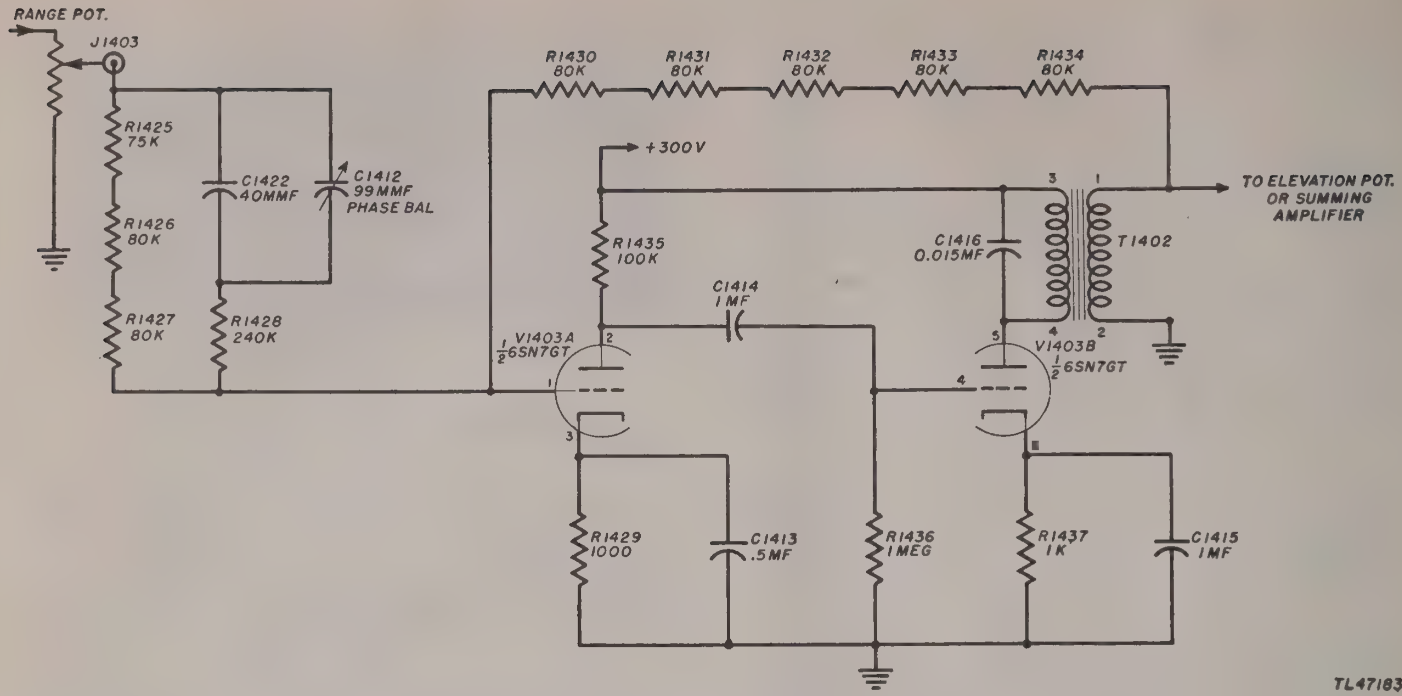

Figure 244. Isolation amplifier, simplified schematic diagram.

reversed once in V1403B, again in V1403A, and again in T1402. The gain then becomes dependent almost completely on the value of resistors R1425 to R1427 and R1430 to R1434. These resistors are precision wound. Resistors R1425, R1426, and R1427 are used also to form 235,000 ohms of the 240,000-ohm load required at the output of the range potentiometer; the additional 5,000 ohms is formed by the effective input impedance of V1403. Capacitor C1412 is the adjustment marked PHASE BAL. This capacitor, in conjunction with capacitor C1422 and resistor R1428, changes the phase shift through the isolation amplifier to compensate for the phase shift in the potentiometer and the interconnecting cables. It is factory set and should not be touched in the field to help in the alignment unless major repairs are needed. Capacitor C1416 is a 250-cycle rough tuning capacitor for the primary of output transformer T1402.

196. SUMMING AMPLIFIER.

a. The summing amplifier is essentially a three-stage amplifier; see figure 245 for a simplified diagram. There are two inputs to this amplifier. Depending upon the setting of switch S1759 or switch S1402, one input receives voltage from either the elevation potentiometer or the range potentiometer (through the isolation amplifier). With switch S1401 in the altitude converter and switch S1759 on the indicator-control panel both in the ALTITUDE position (relay K1401 is de-energized), this amplifier couples the output of the elevation potentiometer to the input of the summing amplifier. With switch S1759 (fig. 246) or switch S1402 in the SLANT RANGE position, this amplifier couples the output of the range potentiometer to one input of the summing amplifier. This is to allow slant range instead of altitude to be transmitted if desired. The switch on the indicator-control panel is used to send slant range to the director at very low angles of elevation, while the switch S1402 on the altitude converter is used primarily for test purposes. The other input receives voltage only from the output of the height potentiometer in the altitude data unit. These two inputs may each be as high as 25 volts but are in such a direction that they balance each other in both amplitude and polarity. If these voltages are not balanced, the unbalance will be amplified by the summing amplifier to drive the altitude spinner motor of the data unit. The altitude spinner motor B1491 drives the height potentiometer in the direction required to balance the input voltages. Resistor R1459 and capacitor C1423 form a phase shifting network designed to make the phase shift of the input voltage to the summing amplifier the same when switch S1402 is in either the ALTITUDE or the SLANT RANGE position.

b. Referring to figure 245, resistors R1442 to R1444 form a 240,000-ohm output, and resistors R1438 to R1441 form a 250,000-ohm output load for the elevation and height potenti-

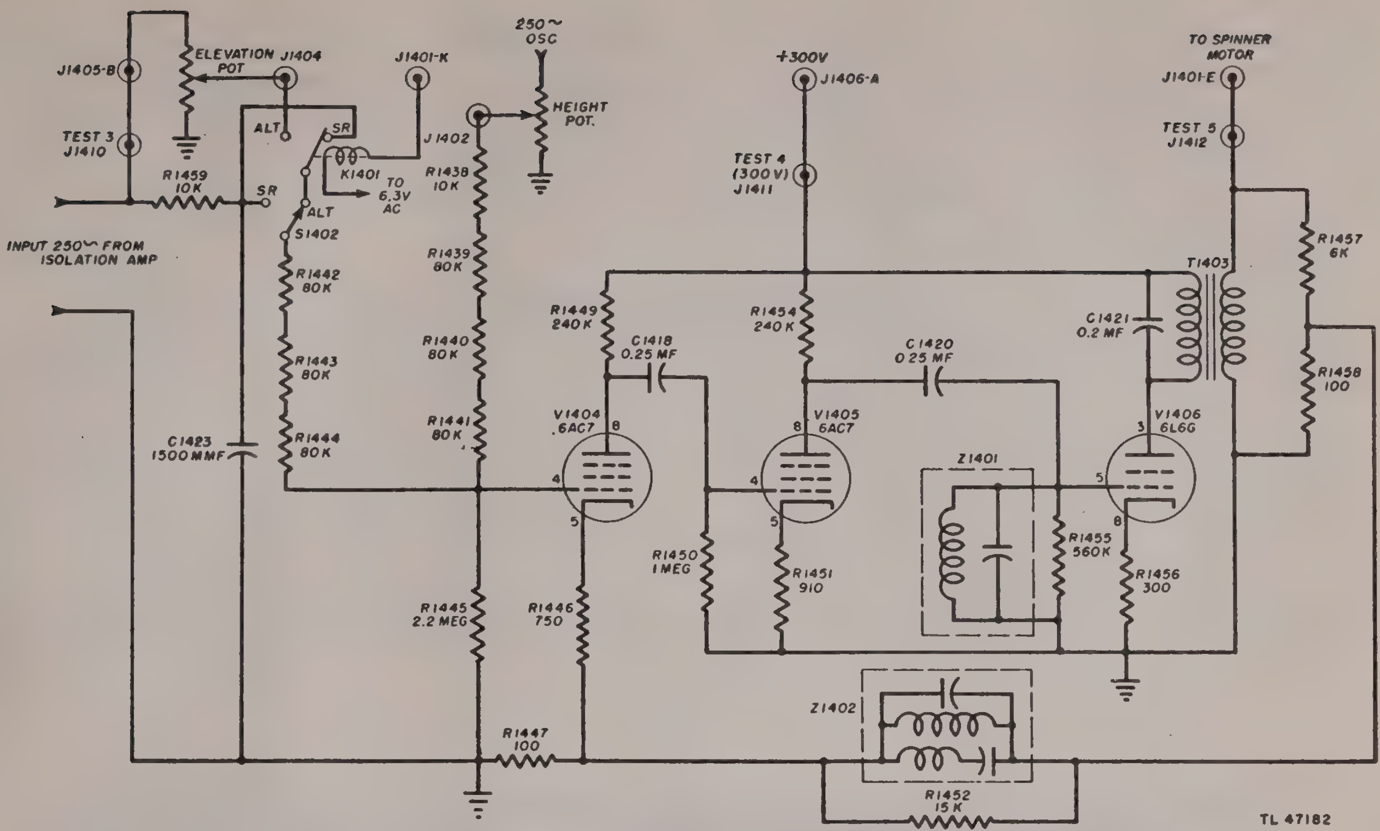

Figure 245. Summing amplifier, simplified schematic diagram.

ometers. Tubes V1404 and V1405 are high-gain voltage amplifiers, resistance-capacitance coupled. Network Z1401 is a 250-cycle tuned circuit used to filter out any noise which may be picked up from other equipment. Vacuum tube V1406 is a 6L6G power tube furnishing approximately 7 watts of power to one field of the spinner motor. Resistors R1457, R1458, R1446, and R1447, with network Z1402, form a negative feedback network used to stabilize the operation of the altitude spinner motor B1491 and the summing amplifier. Network Z1402 has the effect of greatly increasing the output of the summing amplifier with sudden changes of input. This causes the motor to respond rapidly, which is a desirable condition because the motor controls its own input through the height potentiometer. If the motor did not respond quickly

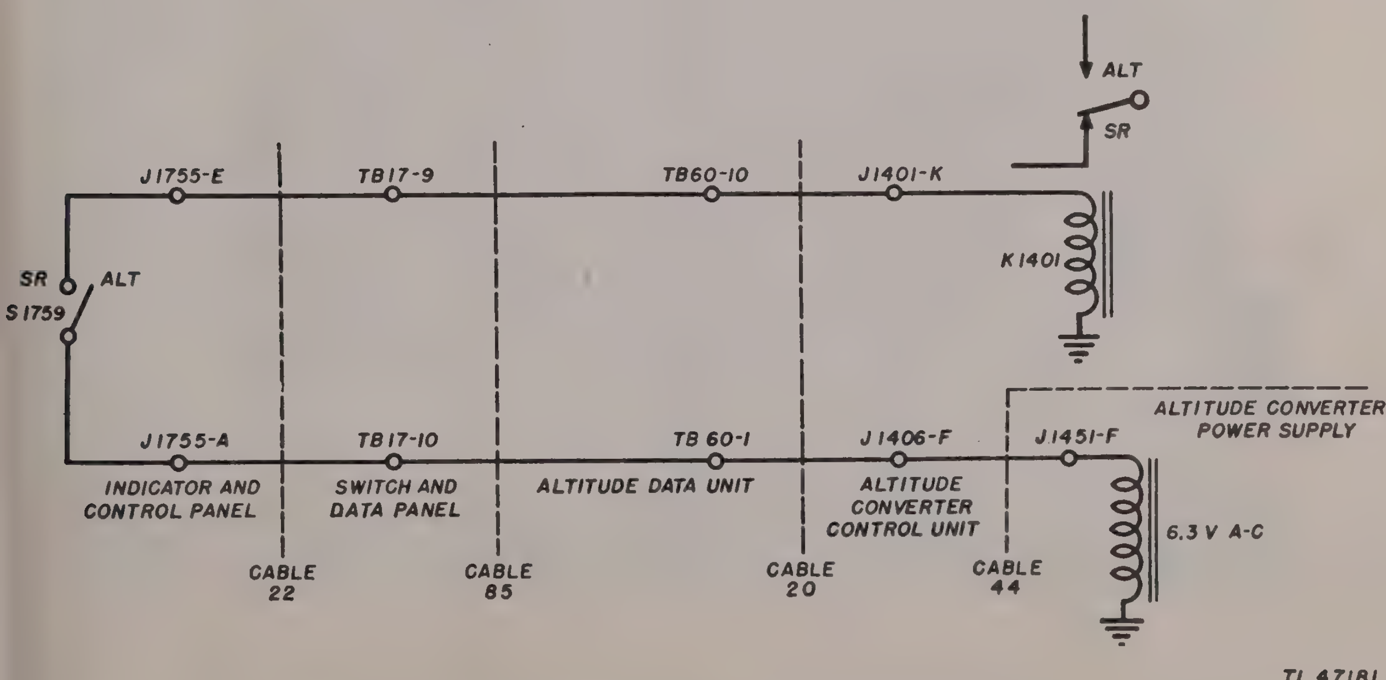

Figure 246. Connections to slant range—altitude relay K1401.

enough to the drop in output that occurs at the proper position of the height potentiometer, it would travel beyond that point and cause an input of the opposite polarity. This would set up an oscillation as overtravel in alternate directions occurred. Resistor R1452 is a limiting resistor for Z1402, so that its action will not be too critical with frequency. Resistor R1445 furnishes bias for grid 4 of V1404 when the potentiometer is disconnected. Capacitor C1421 is a rough tuning capacitor for the primary of output transformer T1409.

SECTION VI
ALTITUDE DATA UNIT AND ALTIMETER

197. ALTITUDE DATA UNIT.

a. General.

(*1*) The altitude data unit (fig. 247) is the unit of the altitude converter system which translates the results of the settings of the elevation and range potentiometers into a dial reading that indicates the height of the target directly in yards. As discussed under the block diagram, the altitude data unit connects not only to the output of the summing amplifier but also to one of its two inputs. The circular system formed by the summing amplifier and data unit may be understood by considering it as acting somewhat like a voltmeter with a powerful indicating movement. Acting as a voltmeter, the system connects to the elevation potentiometer to measure its output voltage. Though the power taken from the potentiometer is negligible, the measured voltage is accurately indicated by the rotation of a comparatively heavy dial and the altitude transmitting selsyn.

(*2*) Because the altitude data unit is located inside the trailer where the dial cannot be seen from the operating position, an auxiliary indicating device called the altimeter is provided. This meter is located on the indicator-control

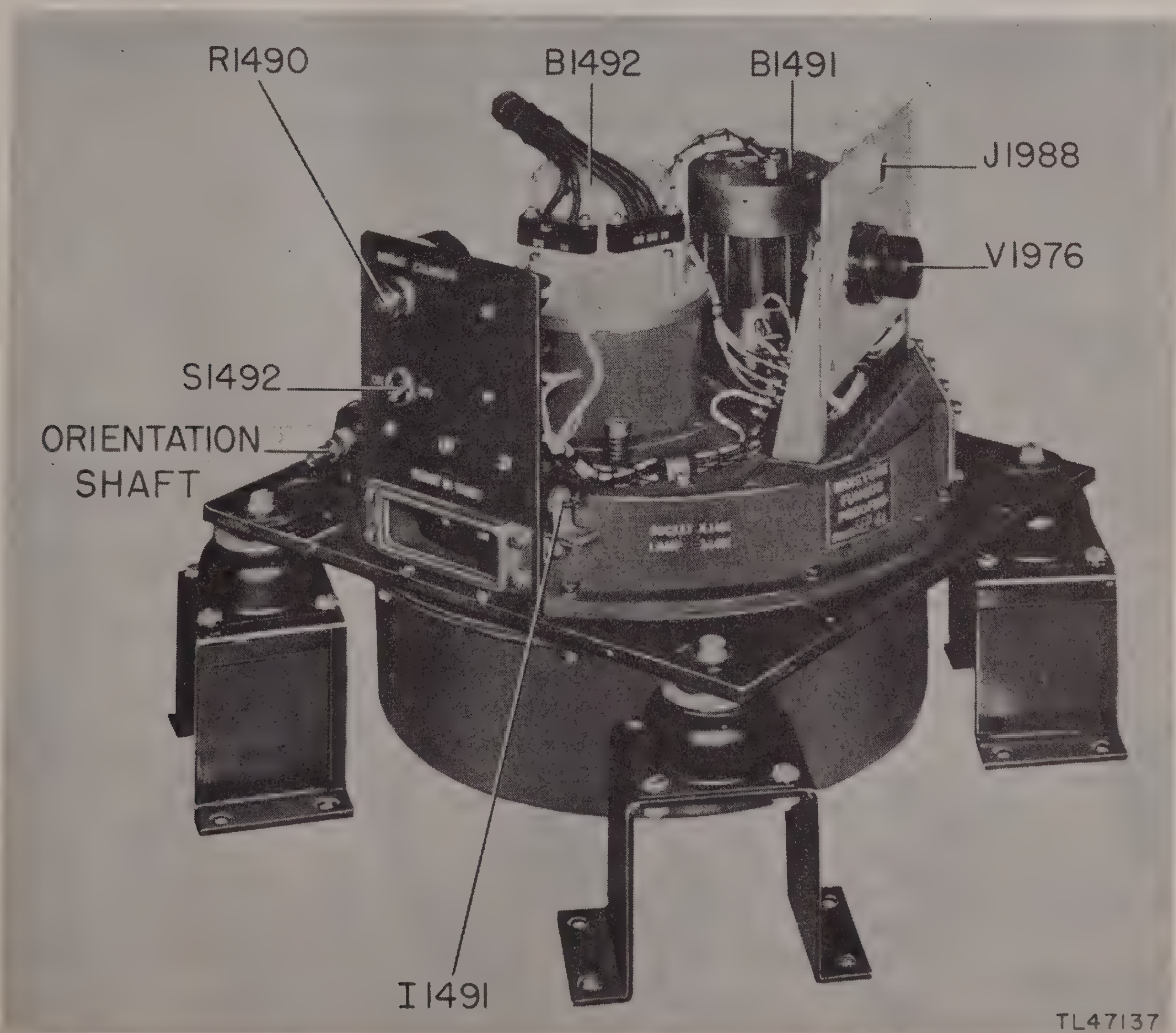

Figure 247. Altitude data unit, cover removed.

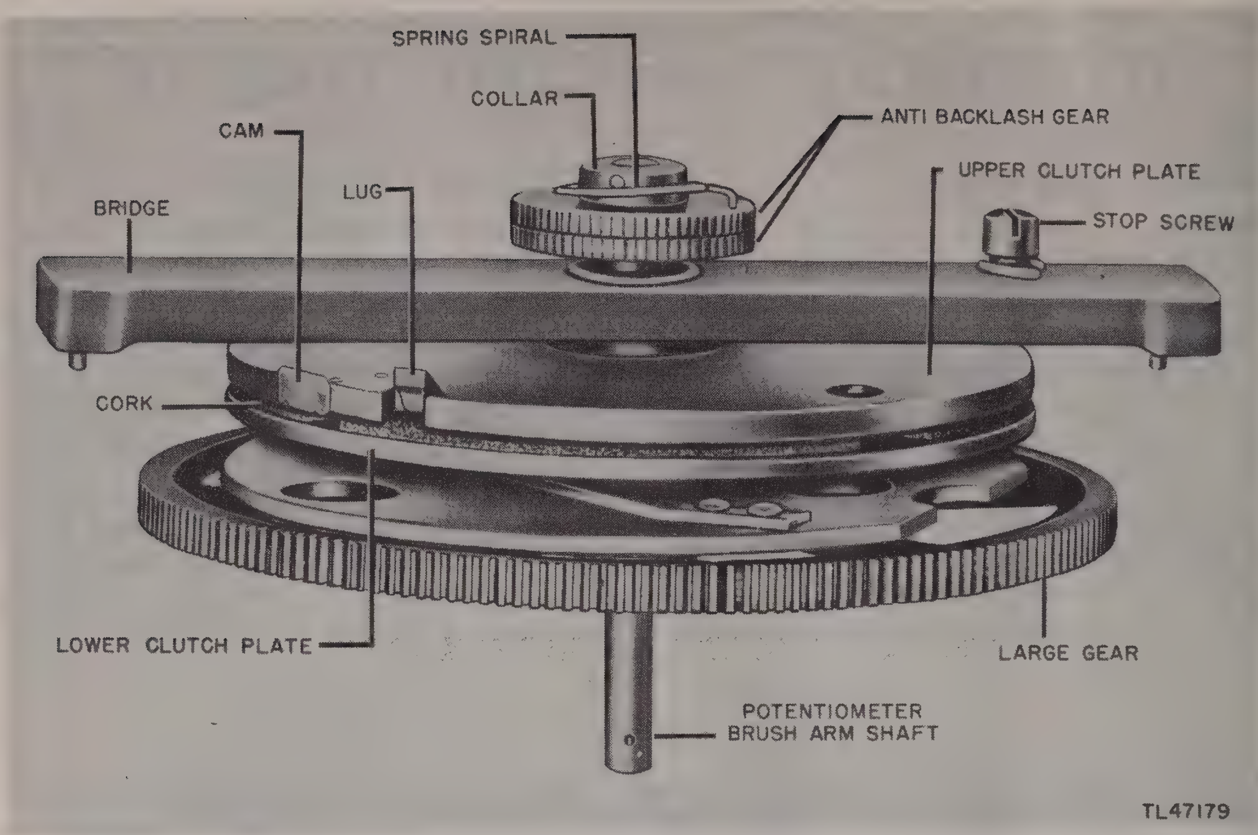

Figure 248. Altitude data unit, main shaft assembly.

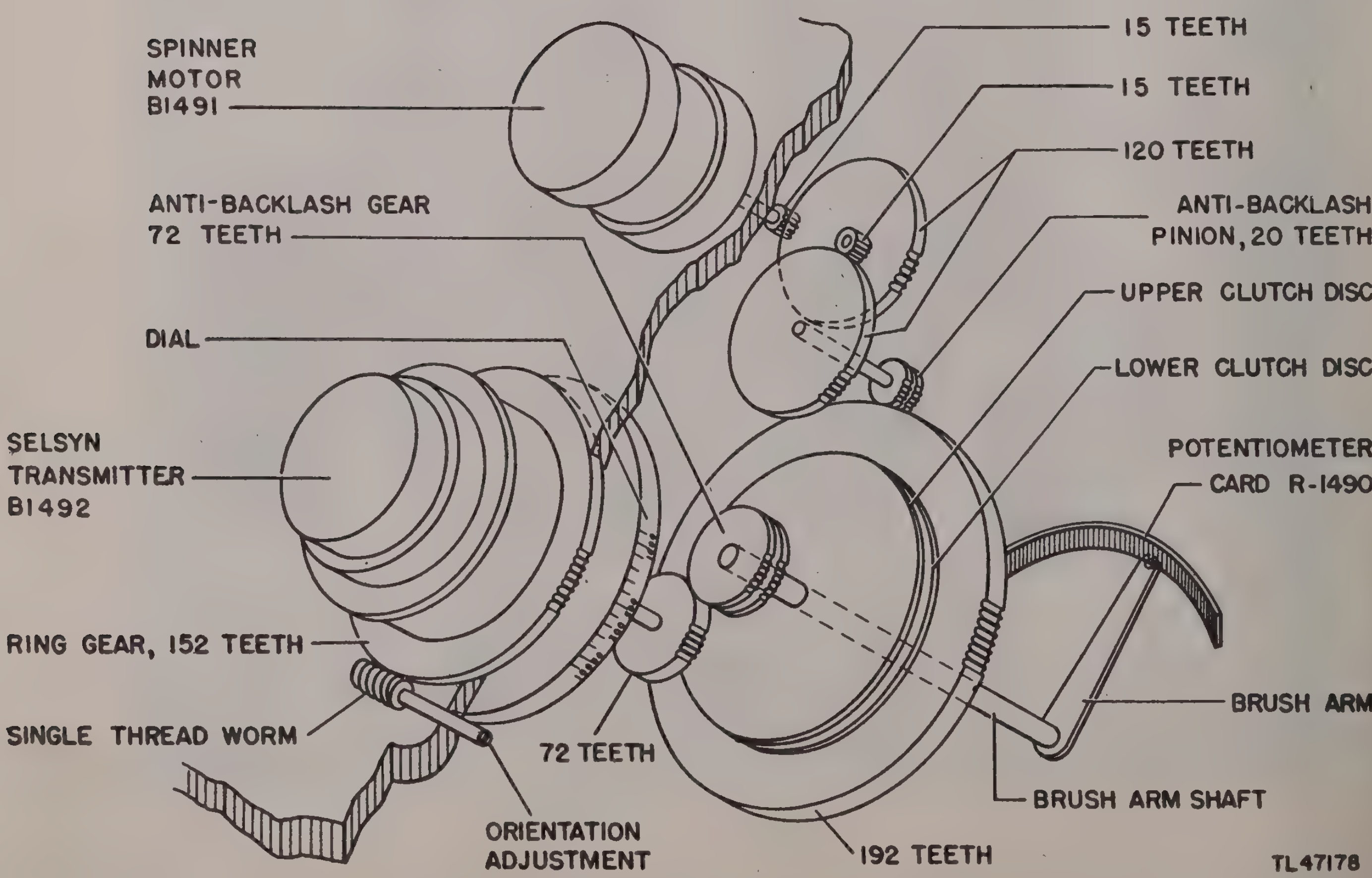

Figure 249. Altitude data unit, phantom view.

panel so that the operator can check on the functioning of the altitude conversion system when the SCR-784 is used with an M7 type gun director, or read altitude when the SCR-784 is used as a search set. The altimeter is a vacuum tube voltmeter that reads the 250-cycle a-c voltage at the arm of the height potentiometer. This voltage is directly proportional to the altitude as read on the altitude dial of the data unit.

b. Mechanical.

(*1*) For an explanation of the mechanical functions performed by the altitude data unit reference should be made to figure 249, which shows a mechanical schematic of the unit; also to figure 248 showing a photograph of the internal mechanism. As shown on figure 249, the altitude spinner motor drives the contact brush arm of the height potentiometer through a train of gears and a disk-type clutch. The potentiometer brush arm in turn is connected through a pair of gears to the data unit dial and selsyn. The gear train between the altitude spinner motor and brush arm consists of a train of six gears having a total gear ratio of 614 to 1. The last gear in this train is the large gear shown in figure 249, which is attached to the potentiometer brush-arm shaft through the disk-type clutch.

(*2*) The details of this clutch are also shown in figure 248. The lower clutch disk and spring assembly is fastened permanently to the large gear, which is free to rotate about its shaft. Two springs are mounted on the clutch disk which exert an upward force to cause the clutch disks to exert pressure against each other and to compress the cork lining which is fastened to the driven disk. As the large gear rotates, it drives the potentiometer brush arm through this clutch. The brush arm shaft, however, is prevented from rotating through the entire arc of 360 degrees and rotates only through an arc equivalent to slightly more than that covered by the dial readings from 300 to 10,000 yards. Beyond this range the cam shown on the brake disk assembly engages a roller which operates the limit switch. The limit switch shunts a resistance across one of the motor windings to reduce the motor torque. If the shaft continues to rotate beyond the limit switch, the lug on the upper clutch disk encounters a stop screw mounted on the bridge casting and brings the potentiometer brush arm shaft to rest. After engaging the stop, the motor and gear train, because of their inertia, may continue to rotate without harm for a short interval, due to the slipping action of the clutch. The gear train connecting the potentiometer brush arm shaft of the altitude selsyn transmitter and the data unit dial is a 1 to 1 ratio two-gear train. The dial and selsyn are therefore directly connected to the potentiometer brush arm and do not operate through the clutch mechanism.

c. Electrical.

(*1*) The schematic of the altitude data unit is shown in figure 257. Part of the altimeter, figure 250, is also mounted in this unit. A fixed voltage of 15 volts, 250 cycles, from the field amplifier of the altitude converter power supply is applied to terminals 3 and 4 of TB60 to excite the fixed field of the altitude spinner motor. The summing amplifier output which varies from a fraction of a volt up to a maximum of approximately 18 volts is applied to terminals 5 and 6 of TB60. The variable field voltage from the summing amplifier is 90 degrees out-of-phase with the fixed field voltage. These voltages are required to operate the two-phase altitude motor. The motor will not run when the variable field voltage falls to a small fraction of a volt.

(*2*) Resistor R1489 associated with the variable field is connected in or out of the circuit by the operation of the limit switch. When the data unit is operated beyond 10,000 yards or below 300 yards, the limit switch is closed as indicated on the schematic circuit diagram and the five-ohm resistor R1489 shunts the variable field of the motor to reduce its power below the point where the motor would continue to drive and cause the clutch mechanism to wear. However, the power is still sufficient for the motor to drive away from the stop when reversed.

(*3*) Terminals 7 and 9 of TB60 connect to the output of the oscillator section of the altitude converter. This voltage is used to excite the winding of the height potentiometer. Resistors R1498 and R1499 and variable resistor R1490 form a network that is used in setting the data unit dial to a reference condition. Resistor R1490 is the HEIGHT CALIBRATE adjustment on the upper left-hand side of the front panel of the data unit. The resistors in series with the potentiometer winding are called pad-out resistors. These resistors are used to make the over-all potentiometer resistance 20,000 ohms and to add the resistance required at the

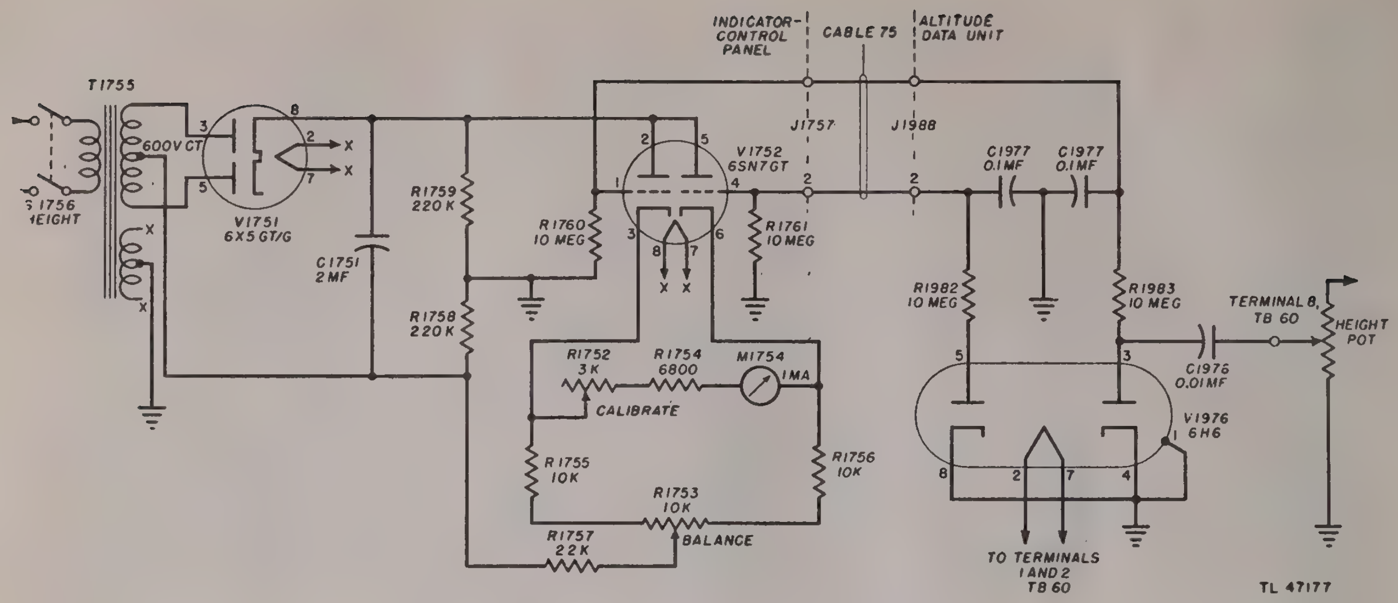

Figure 250. Altimeter, schematic diagram.

end of the potentiometer winding because the potentiometer goes down only to 300 yards on the card.

(*4*) Terminal 8 of TB60 is the height potentiometer output connection from the contact brush and goes to one of the two inputs of the summing amplifier. Except for its slightly smaller diameter, the height potentiometer is essentially similar in construction and in basic operation to the range potentiometer. When the unit is in operation 6.3 volts a-c is applied through terminals 1 and 2 of terminal block TB60 to lamp I1491 which is controlled by switch S1492. Terminal 10 of TB60 is connected to cable 85. This line from terminal 10 on TB60 is one of the connections for the slant range-altitude relay, K1401 (fig. 246) in the altitude converter unit. Terminals 1 to 5 on terminal block TB61 are the terminals which connect to the altitude selsyn transmitter. This selsyn is used for the purpose of transmitting the altitude data to M7 type directors.

198. ALTIMETER.

a. The schematic of the altimeter is shown in figure 250. A rear view of the indicator control panel showing the location of the components is shown in figure 251. The voltage from the height potentiometer arm is coupled through C1976 to plate 3 of V1976. This section of the tube is a half-wave rectifier, developing d-c voltage across R1983 and R1760 in series. At first glance it might appear that the diode would load the height potentiometer heavily during the half-cycle when the diode is conducting. However C1976 charges to a d-c voltage nearly equal to the peak a-c voltage. After C1976 is fully charged the diode conducts during only enough of the half-cycle to replace the charge that leaks off through R1983 and R1760. These resistances are made large to reduce the loading on the potentiometer. Only half the d-c voltage is applied to grid 1 of V1762, in order to insure that operation remains on the linear part of the tube characteristic curve. Capacitor C1977 smooths out the voltage applied to the grid. The center of the voltage divider across the power supply output is grounded to provide a positive voltage for the plates and a negative voltage for the cathodes. However, the current drawn by plate 2 of V1752 flows through R1757, about half of R1753, and R1755, so that cathode 3 is nearly at ground potential with minimum altitude voltage input. When the altitude increases, the a-c voltage applied to the diode becomes larger, the d-c voltage at grid 1 becomes more negative, and the cathode potential also becomes more negative. Because the potential at grid 4 of V1752 remains the same, the potential of cathode 6 tends to remain the same and the difference of potential at the two cathodes causes a current to flow through R1752, R1754, and M1754. Resistor R1752 is adjusted with the height potentiometer at maximum (10,000 yards) to make the meter read full scale.

b. A dual triode is used in the altimeter so that changes in plate voltage will affect both sections of the tube the same way. If the current through one section changes due to a plate voltage change, the current in the other will change the same amount, and the meter

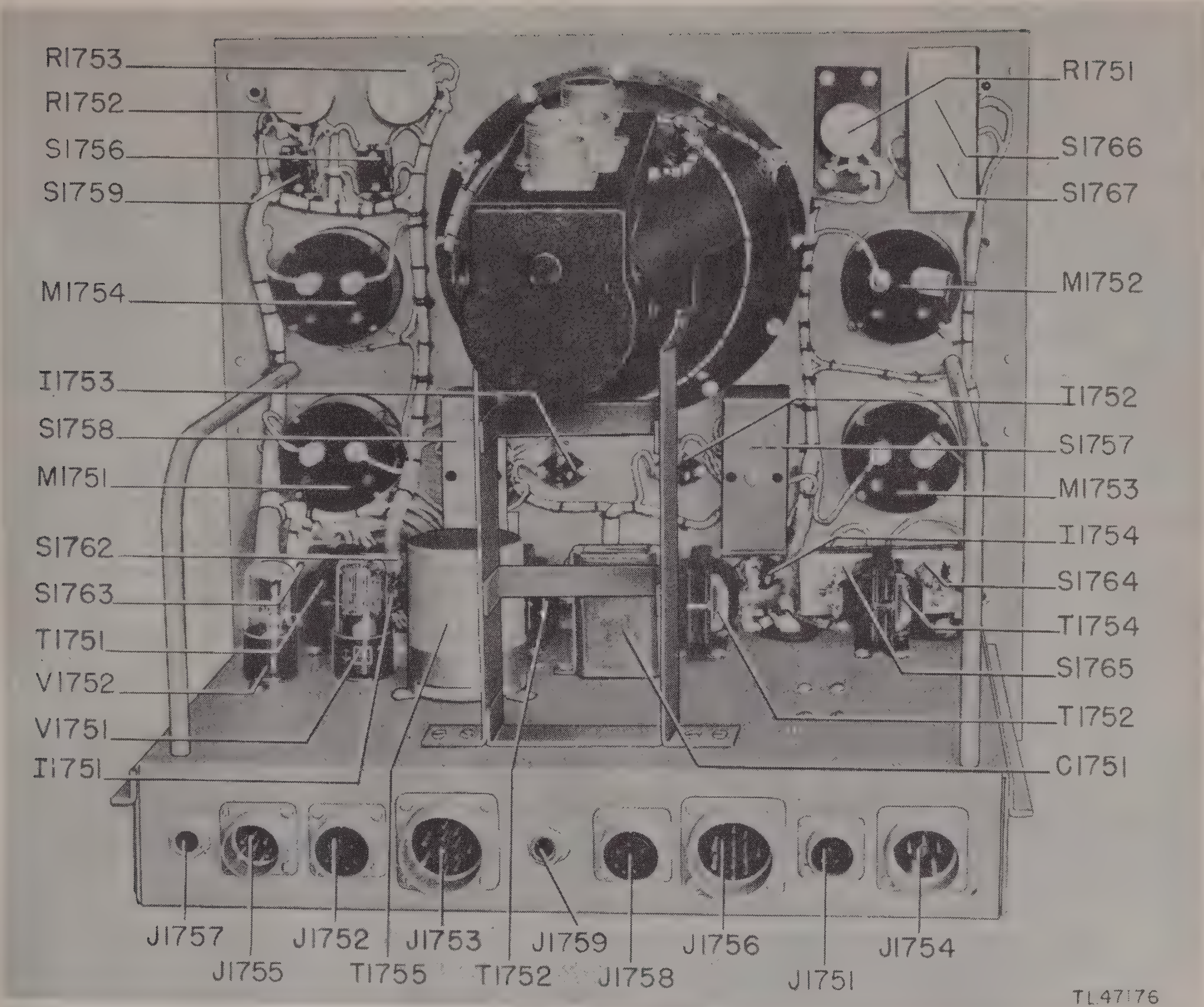

Figure 251. Indicator-control panel, rear view.

reading will not be affected. The second diode in V1976, R1982, the second section of C1977, and R1761 are included in the circuit so that equal contact potentials and equal diode space charge potentials will be applied to the grids of V1752. This completes the symmetry of the circuit and allows the currents through V1752 to be perfectly balanced by R1753 with the height potentiometer at zero altitude. In practice, however, the balancing cannot be done at zero altitude because the height potentiometer card extends only to 300 yards.

SECTION VII

ALTITUDE CONVERTER POWER SUPPLY

199. INTRODUCTION.

The altitude converter power supply, Rectifier RA-70-A, shown in figure 252, contains two sections. One is a voltage regulated power supply similar to those discussed previously but with a different amplifier for voltage changes. The other section is a field amplifier which applies a constant voltage to one field of the altitude spinner motor. The complete schematic diagram is shown in figure 256.

200. POWER SUPPLY.

a. A brief description of the more important elements in the power supply section will clarify the manner in which it operates. Referring to the simplified schematic, figure 253, a full-wave rectifier employing a twin-diode rectifier tube, V1452, is connected to a single section filter consisting of inductor L1451 and capacitor C1451. The output of the filter is fed through a parallel combination of two triode regulating tubes V1453 and V1454 to the output terminals of the unit. Variations of the output voltage over a range of ± 15 volts from the output voltage of 300 volts is obtained by adjusting potentiometer R1462, designated VOLTAGE CONTROL.

b. In operation, the voltage from the rectifier and filter varies with load and the line voltage changes, but the voltage at the output terminals of the unit is maintained at a constant value by varying the voltage drops across the regulator tubes V1453 and V1454. The action of the control tubes V1455 and V1456 is considerably more involved, but has the same final results as in the other power supplies.

c. Refer to figure 253 during the following discussion. A reference voltage furnished by the

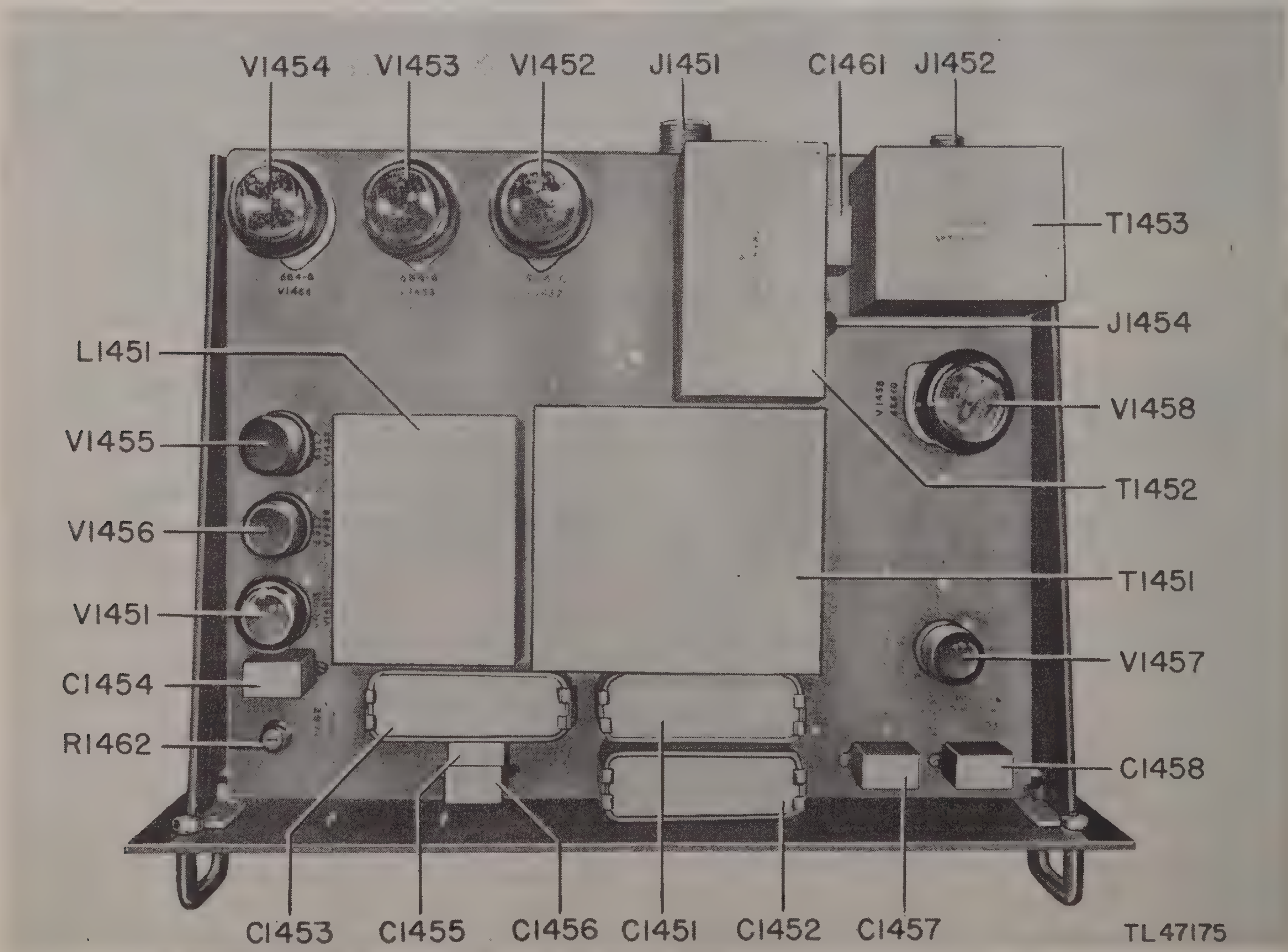

Figure 252. Altitude converter power supply, top view.

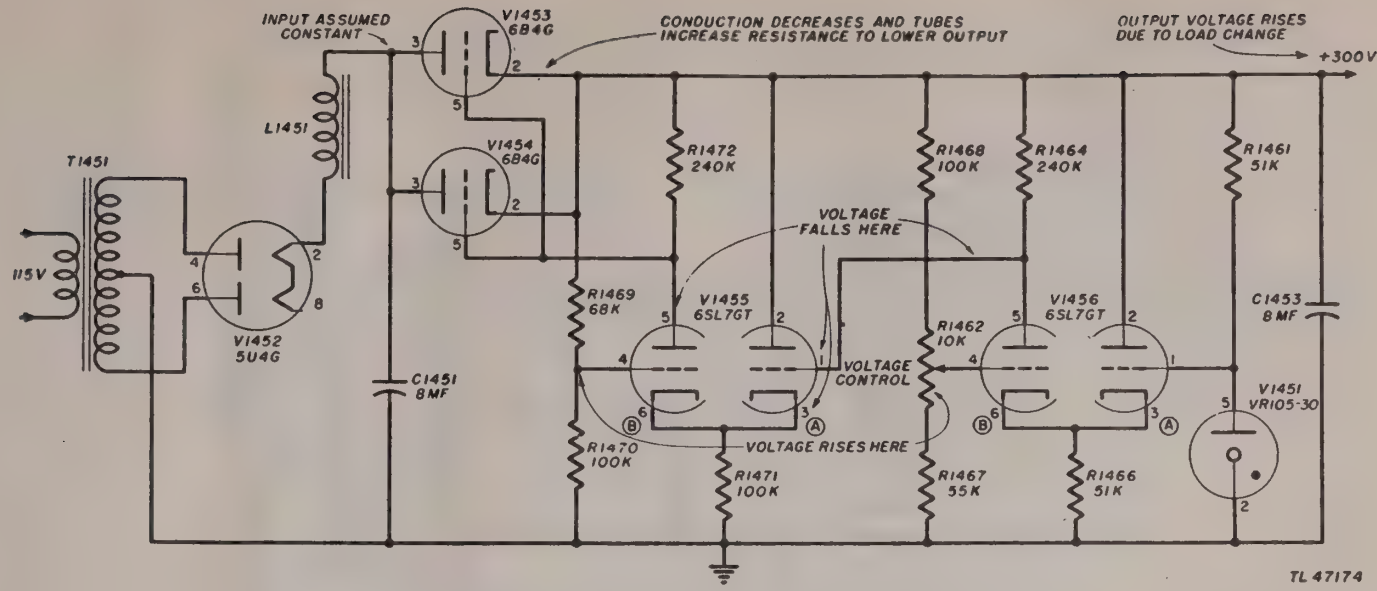

Figure 253. Altitude converter power supply, simplified schematic diagram.

constant voltage drop across the gas tube V1451 is applied to grid 1 of V1456A, which carries virtually all of the total tube current because of the large resistor R1464 in the plate circuit of V1456B. Therefore, the total current of V1456 is practically independent of small changes in the output voltage and the voltage drop across the cathode resistor R1466 is virtually constant and effectively the constant reference voltage has been transferred to the cathode circuit of V1456.

d. Grid 4 of V1456B is connected to the contact arm of potentiometer R1462 which, in series with resistors R1468 and R1467 is connected across the output of the power supply. Variations of output voltage, therefore, changes the grid voltage and the amplified change appears with opposite polarity at plate 5 of V1456B. This plate potential is applied to grid 1 of V1455A which functions as a cathode follower and by its control of the cathode current through resistor R1471 controls the grid bias on V1455B. This action takes place because the cathodes (which are connected together) rise in voltage when grid 1 goes more positive and fall in voltage when grid 1 becomes less positive. The resulting voltage swing is large compared to the change in output voltage because of the amplifying action of V1456B which now has a large signal applied to its cathode while its grid remains almost constant because it is connected to the voltage divider consisting of R1469 and R1470. Varying the cathode voltage of a tube while keeping the grid constant is a way of applying a signal to a tube to get a variation in the plate voltage without inverting the signal. For example, when the cathode falls in voltage, the grid effectively becomes more positive, the tube conducts more and the plate voltage falls because of the greater voltage drop in the plate resistor. This is the action which takes place in V1455B. The slight grid variations due to output voltage changes happen to be of such a polarity that they increase the action and therefore V1455B becomes a very good amplifier of changes in output voltage. The voltage drop across the plate resistor R1472 is essentially the grid bias of the regulator tubes V1453 and V1454. Thus, the variation of this bias is simply the change of output voltage after it has been highly amplified. As a result, the voltage drop across the regulator tubes, which subtracts from the basic supply, varies with small changes of output voltage in such a manner that the output voltage remains essentially constant.

201. FIELD AMPLIFIER.

a. The field amplifier section consists of a two-stage amplifier in which a type 6SJ7GT vacuum tube V1457 is resistance-capacitance coupled to a type 6L6G power amplifier output tube V1458. The input to this amplifier (fig. 254) approximately 4 volts, operates directly into grid 4 of V1457. The amplifier output transformer T1453 is designed to operate into a load of approximately 30 ohms. Resistor R1477 in conjunction with cathode resistor R1474 forms

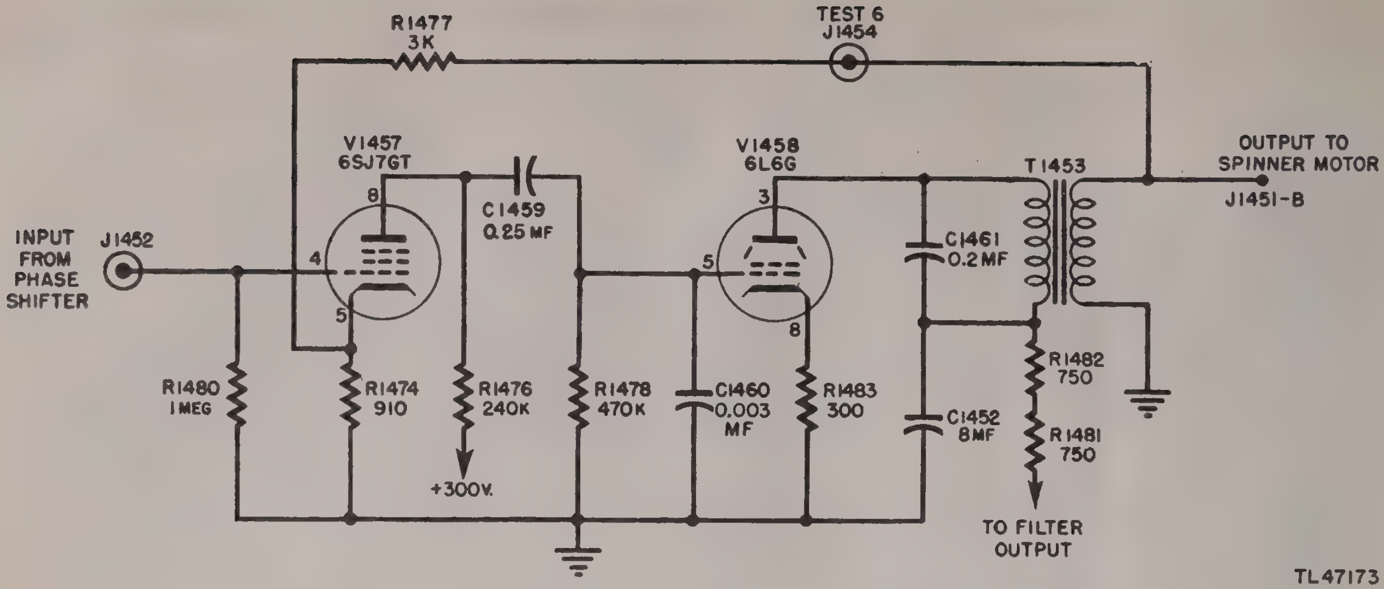

Figure 254. Field amplifier, simplified schematic diagram.

a negative feedback path to maintain the gain of this amplifier substantially constant. It also has the advantage of making the amplifier output voltage, to some extent, independent of variations in the altitude spinner motor.

b. Resistor R1480 is the ordinary grid load resistor for V1457. Capacitor C1460 is used to reduce the amplifier gain at high frequencies in order to prevent oscillation or singing as a result of the negative feedback design of this amplifier. Capacitor C1461 is the rough tuning capacitor to tune the primary of output transformer T1453 to approximately 250 cycles.

c. The plate and screen supply for V1457 and the screen supply for V1458 are supplied from the regulated 300-volt output of the power supply section. The plate supply for V1458, however, is not obtained from the regulated 300-volt supply of the power supply section but from the output of the rectifier filter. Resistors R1481 and R1482 are used in making this connection. The purpose of this connection is to obtain a voltage higher than 300 volts on the plate of V1458 to increase the power output.

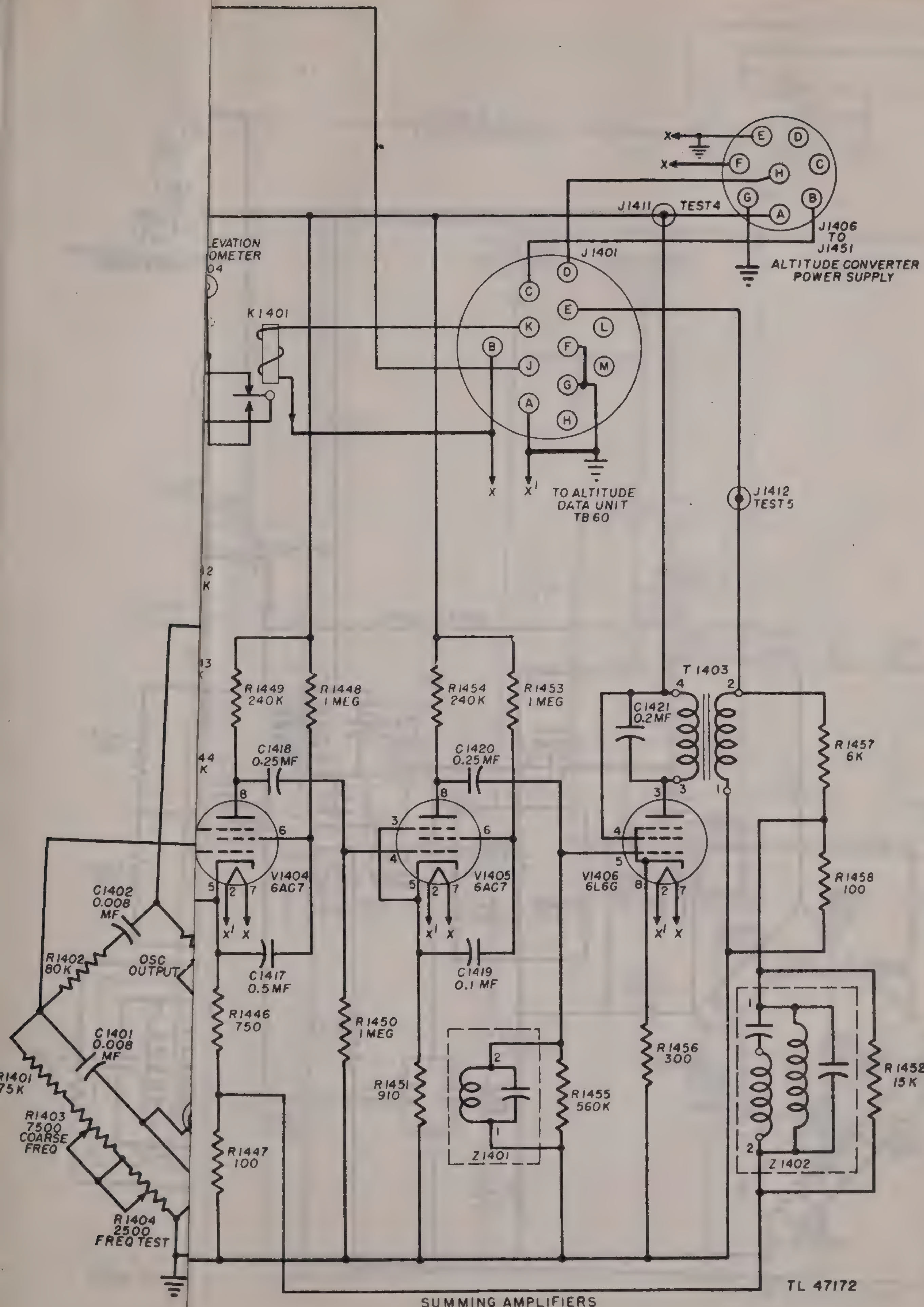

Figure 255. Altitude converter unit, complete schematic diagram.

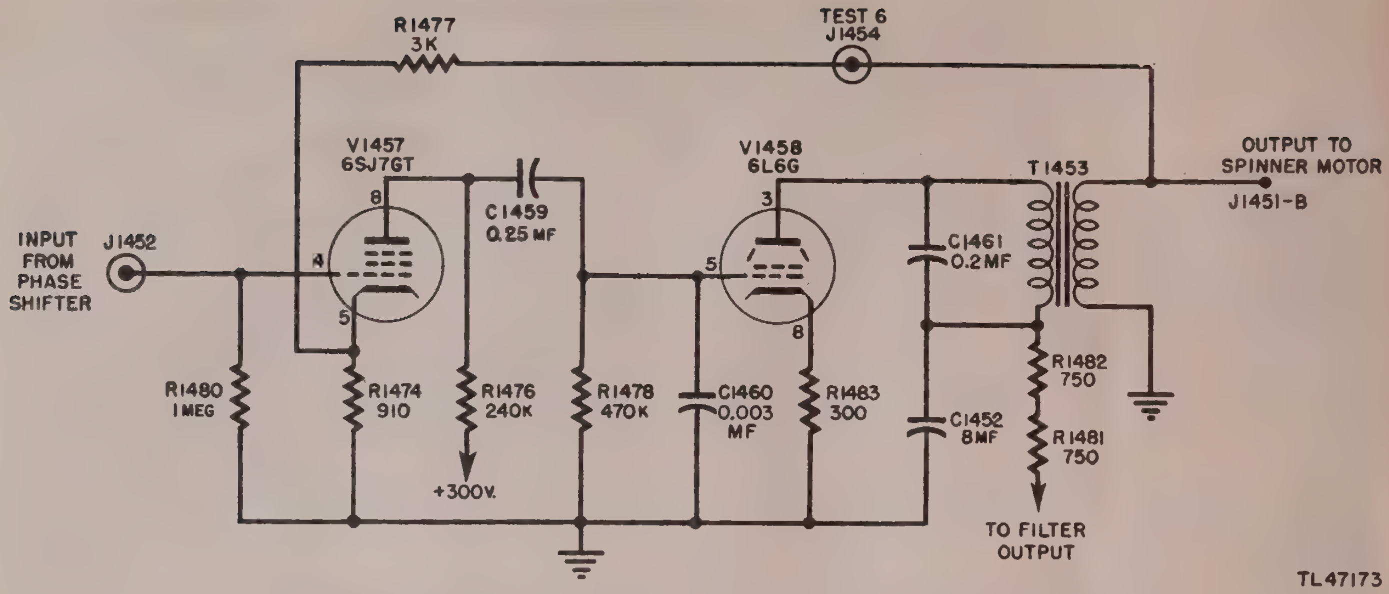

Figure 254. Field amplifier, simplified schematic diagram.

a negative feedback path to maintain the gain of this amplifier substantially constant. It also has the advantage of making the amplifier output voltage, to some extent, independent of variations in the altitude spinner motor.

b. Resistor R1480 is the ordinary grid load resistor for V1457. Capacitor C1460 is used to reduce the amplifier gain at high frequencies in order to prevent oscillation or singing as a result of the negative feedback design of this amplifier. Capacitor C1461 is the rough tuning capacitor to tune the primary of output transformer T1453 to approximately 250 cycles.

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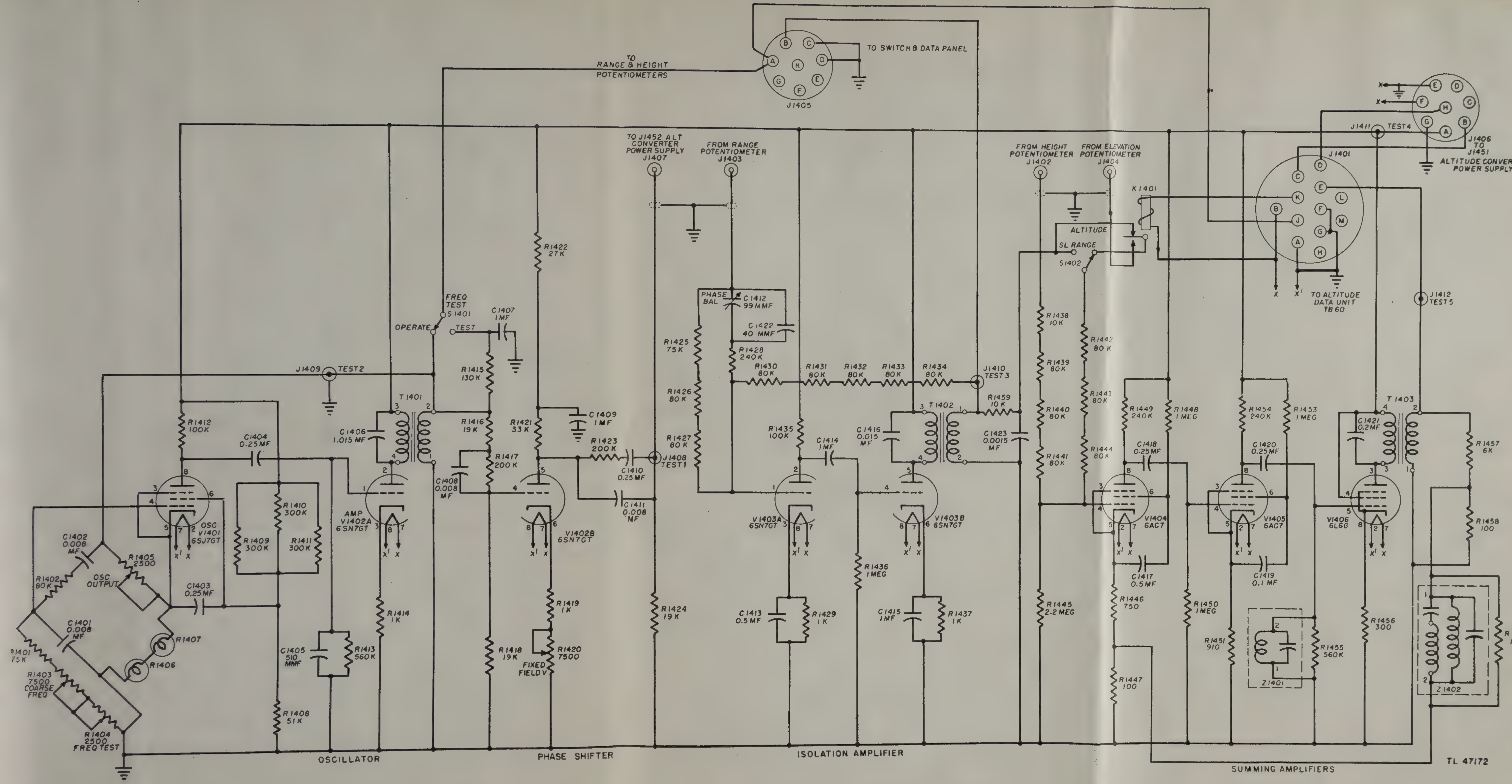


Figure 255. Altitude converter unit, complete schematic diagram.

Figure 255. Altitude converter unit, complete schematic diagram.

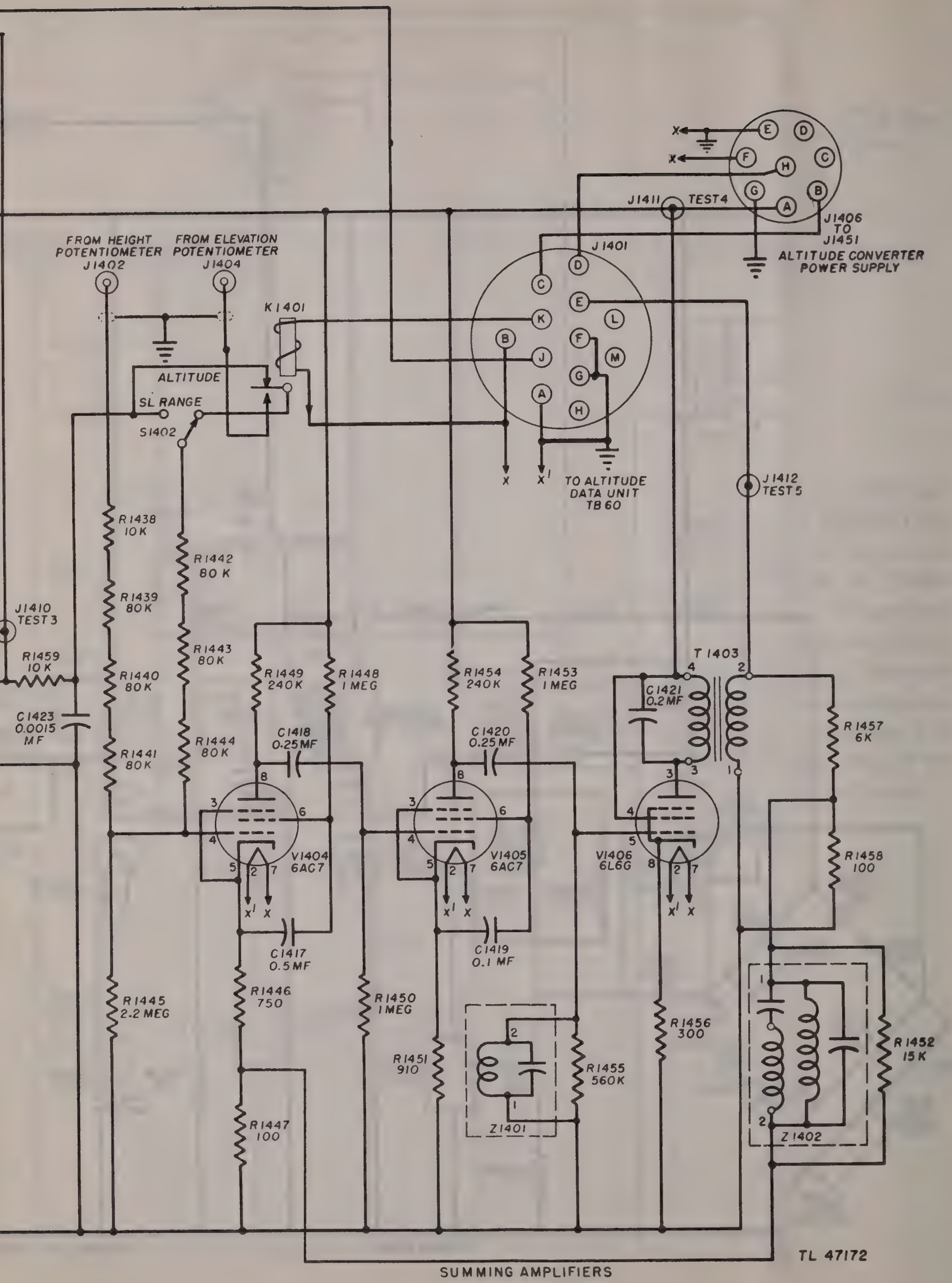


Figure 255. Altitude converter unit, complete schematic diagram.

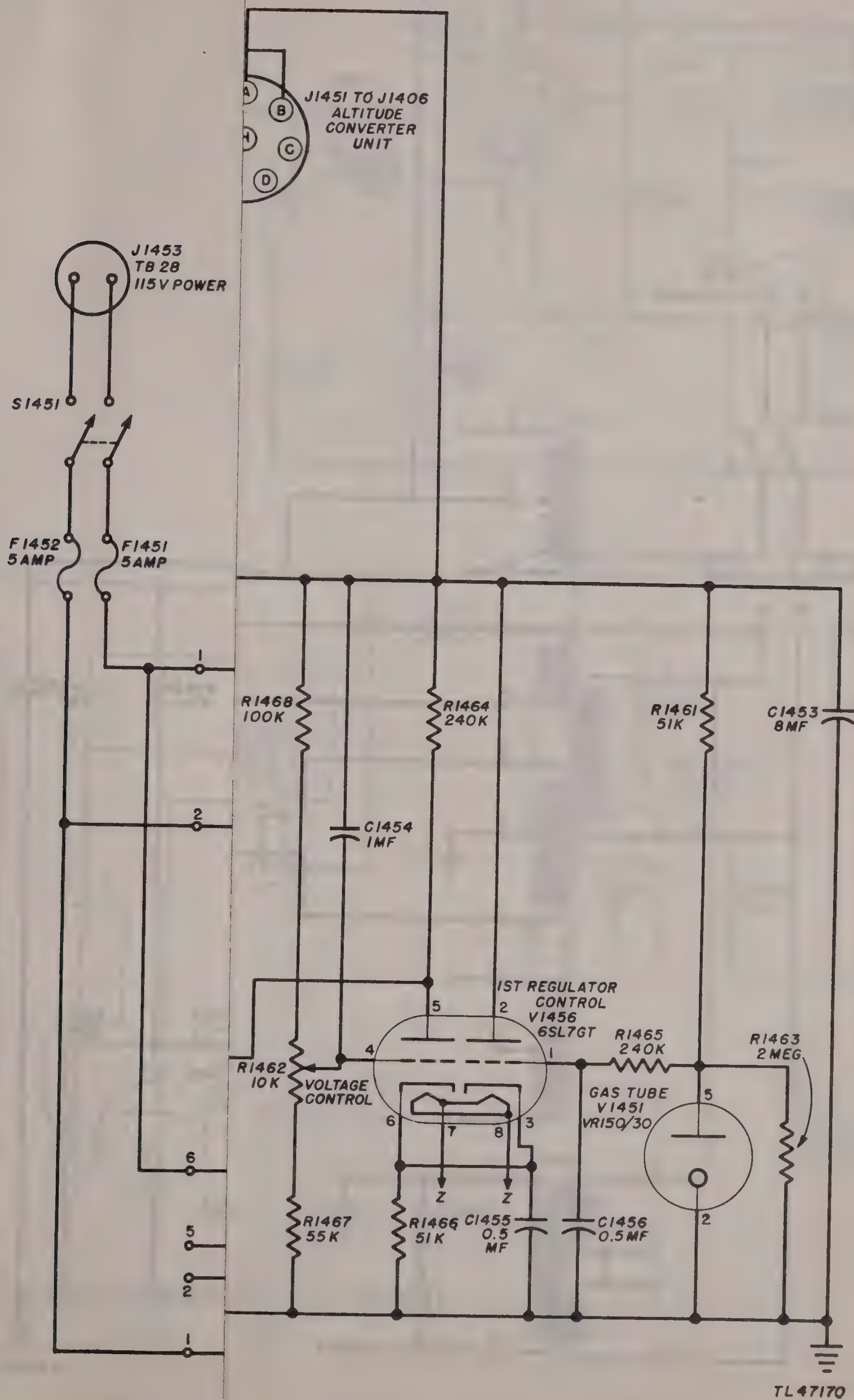


Figure 256. Altitude converter power supply, complete schematic diagram.

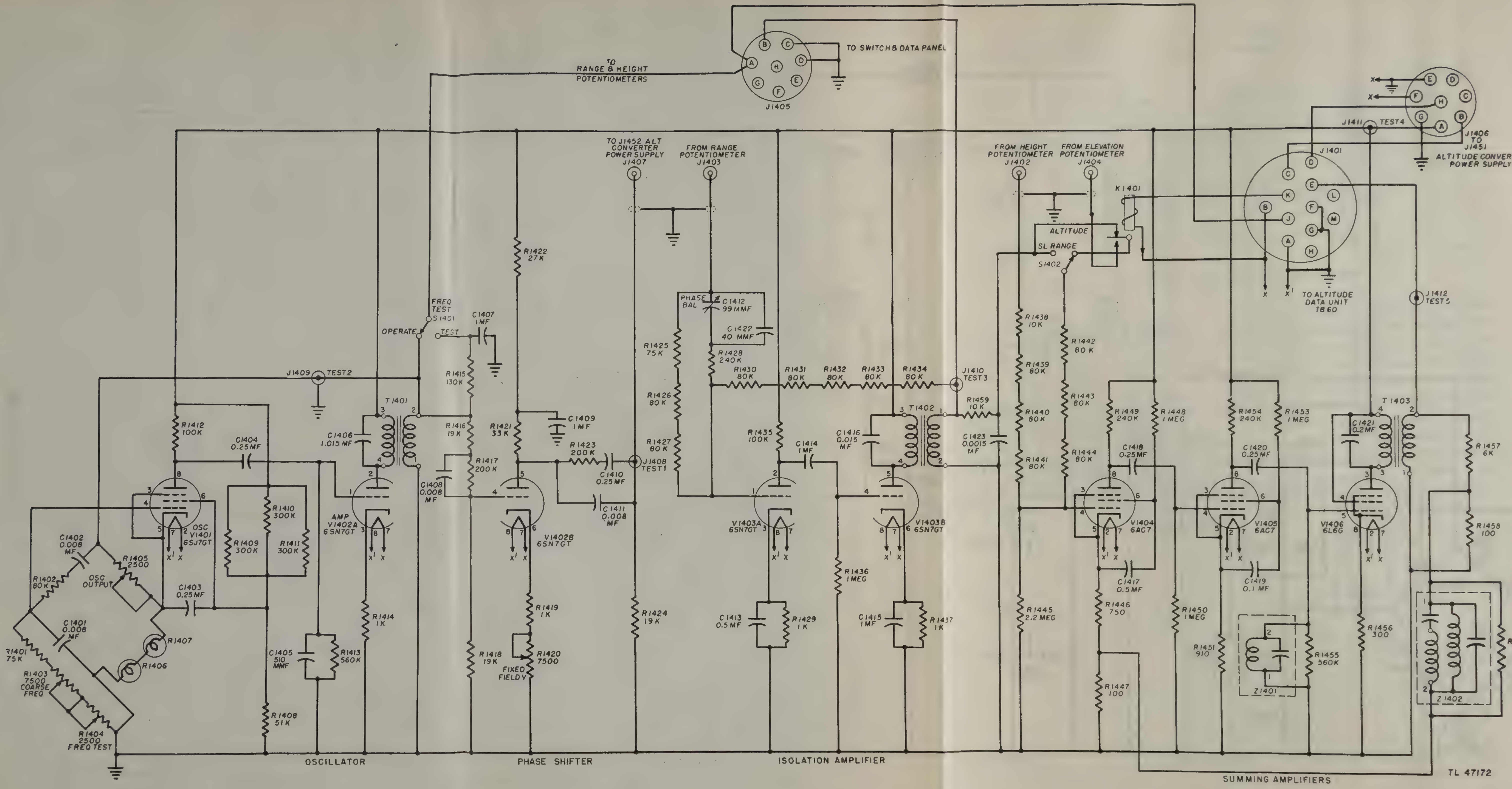


Figure 255. Altitude converter unit, complete schematic diagram.

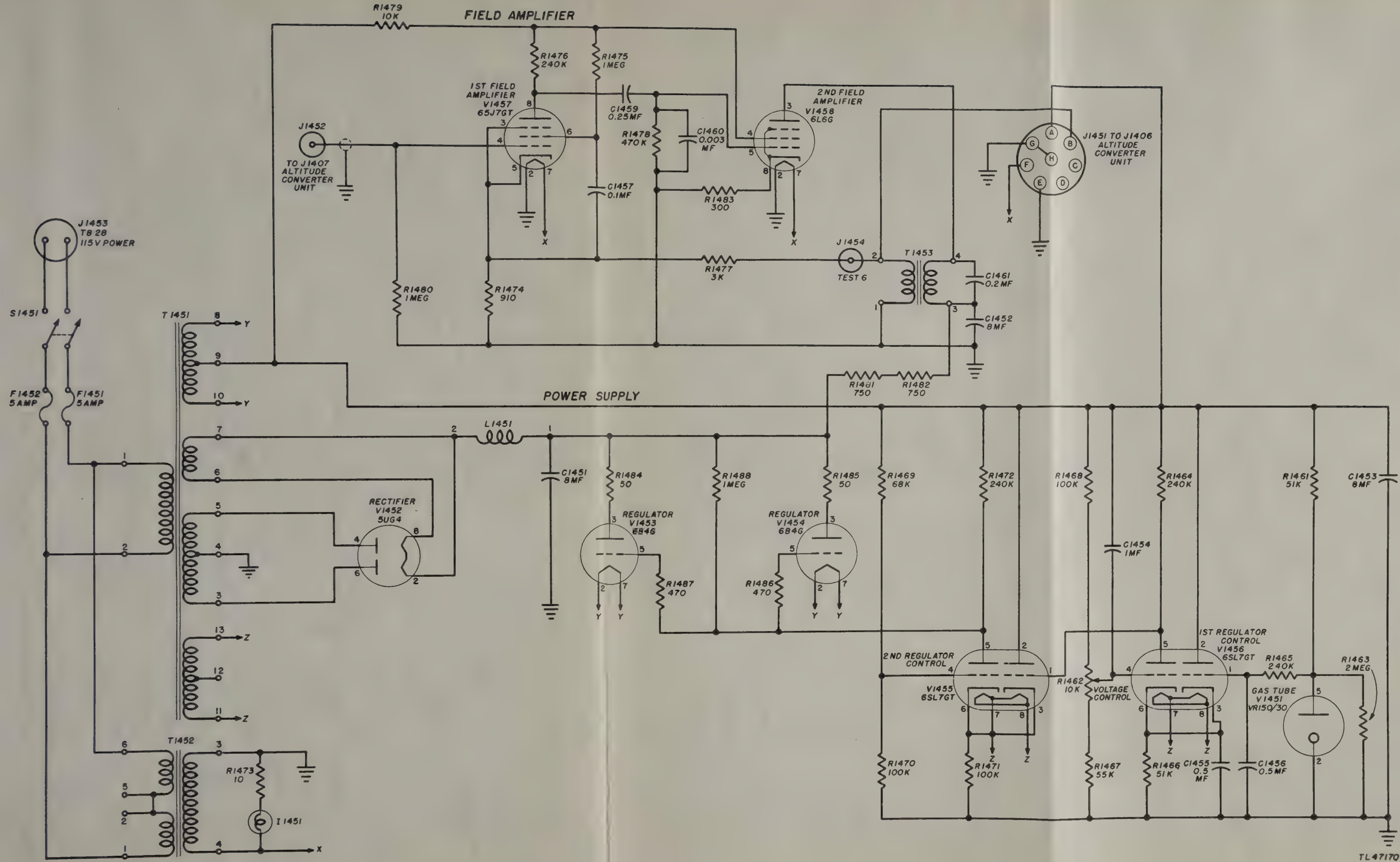


Figure 256. Altitude converter power supply, complete schematic diagram.

Figure 256. Altitude converter power supply, complete schematic diagram.

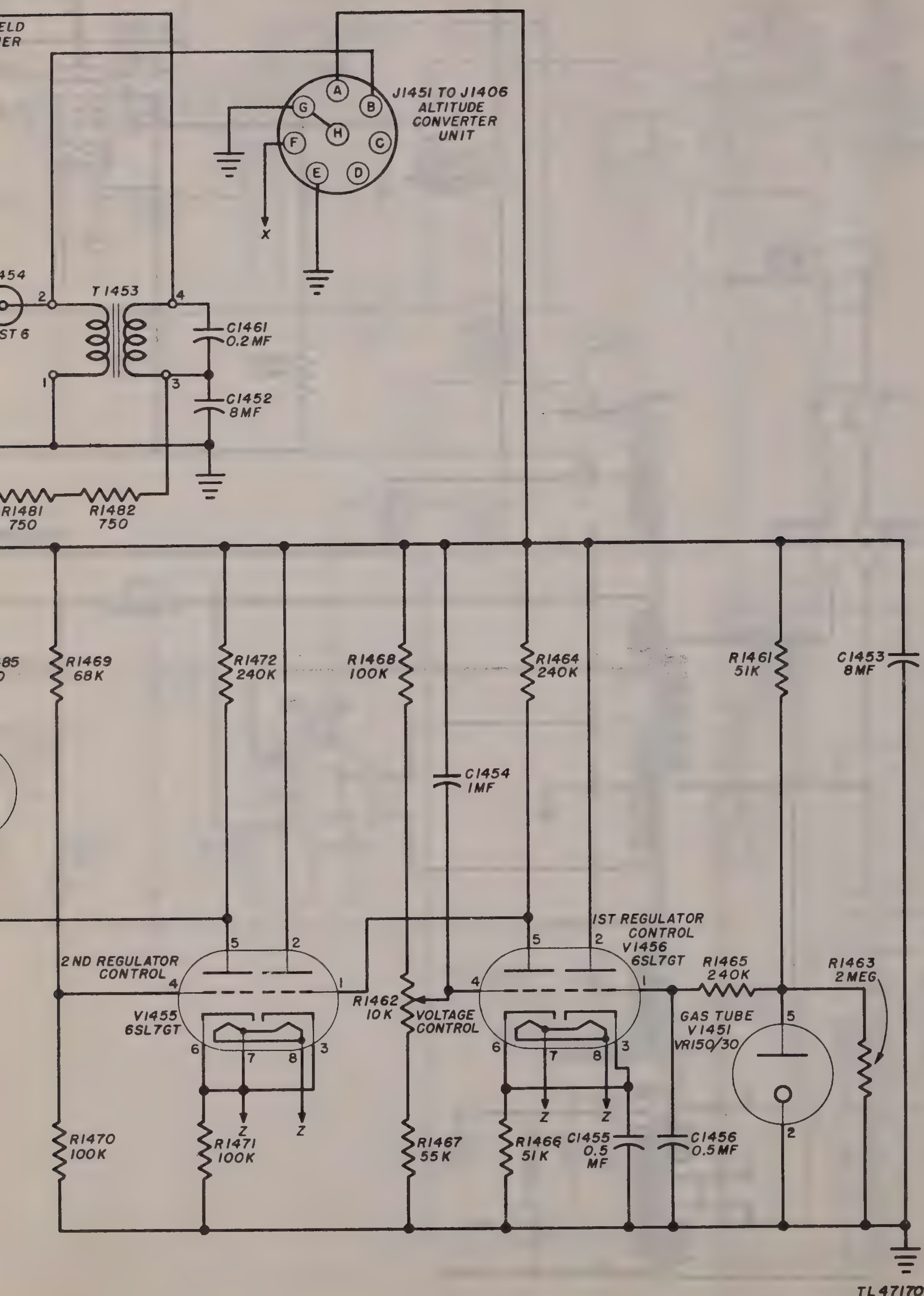


Figure 256. Altitude converter power supply, complete schematic diagram.

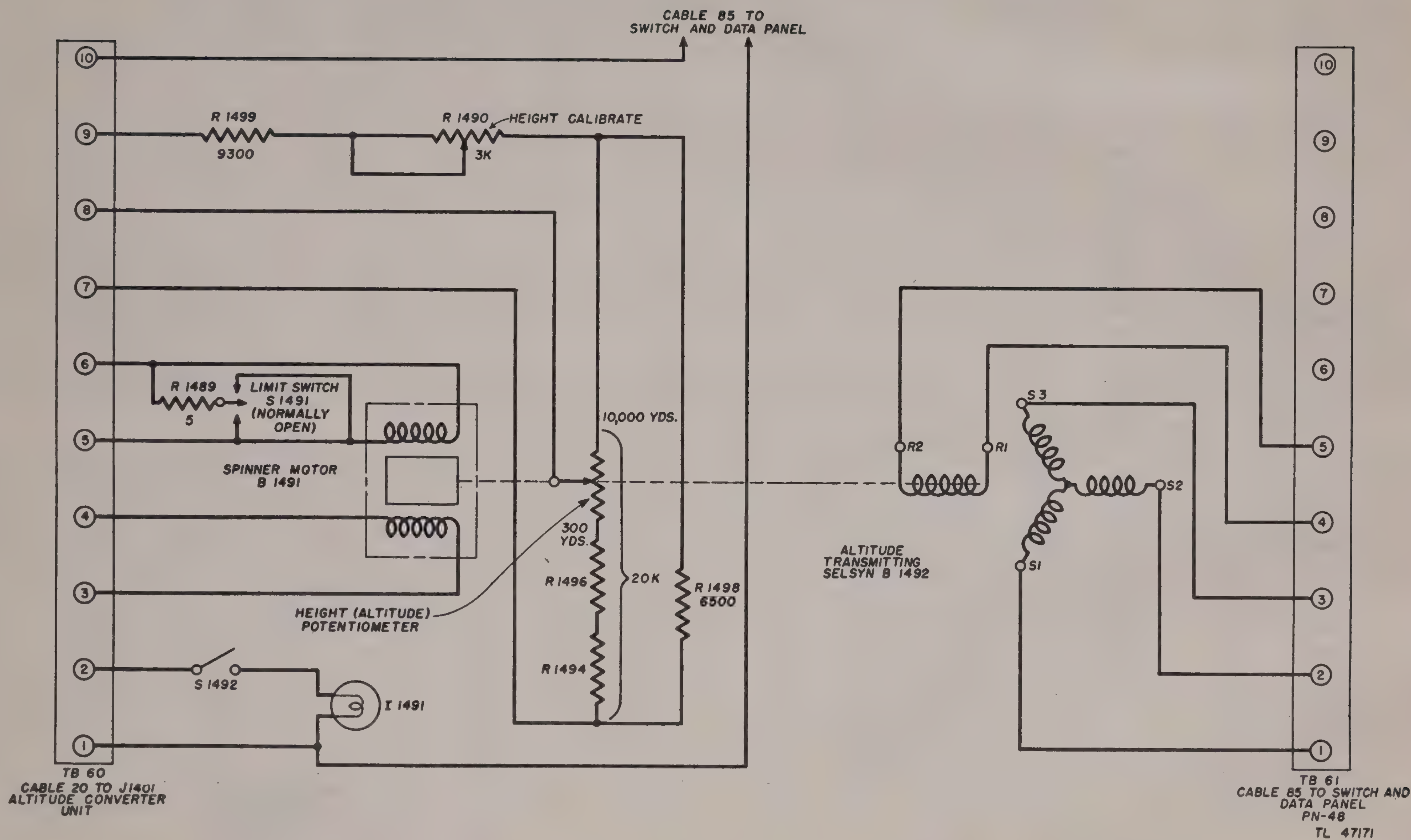


Figure 257. Altitude data unit, complete schematic diagram.

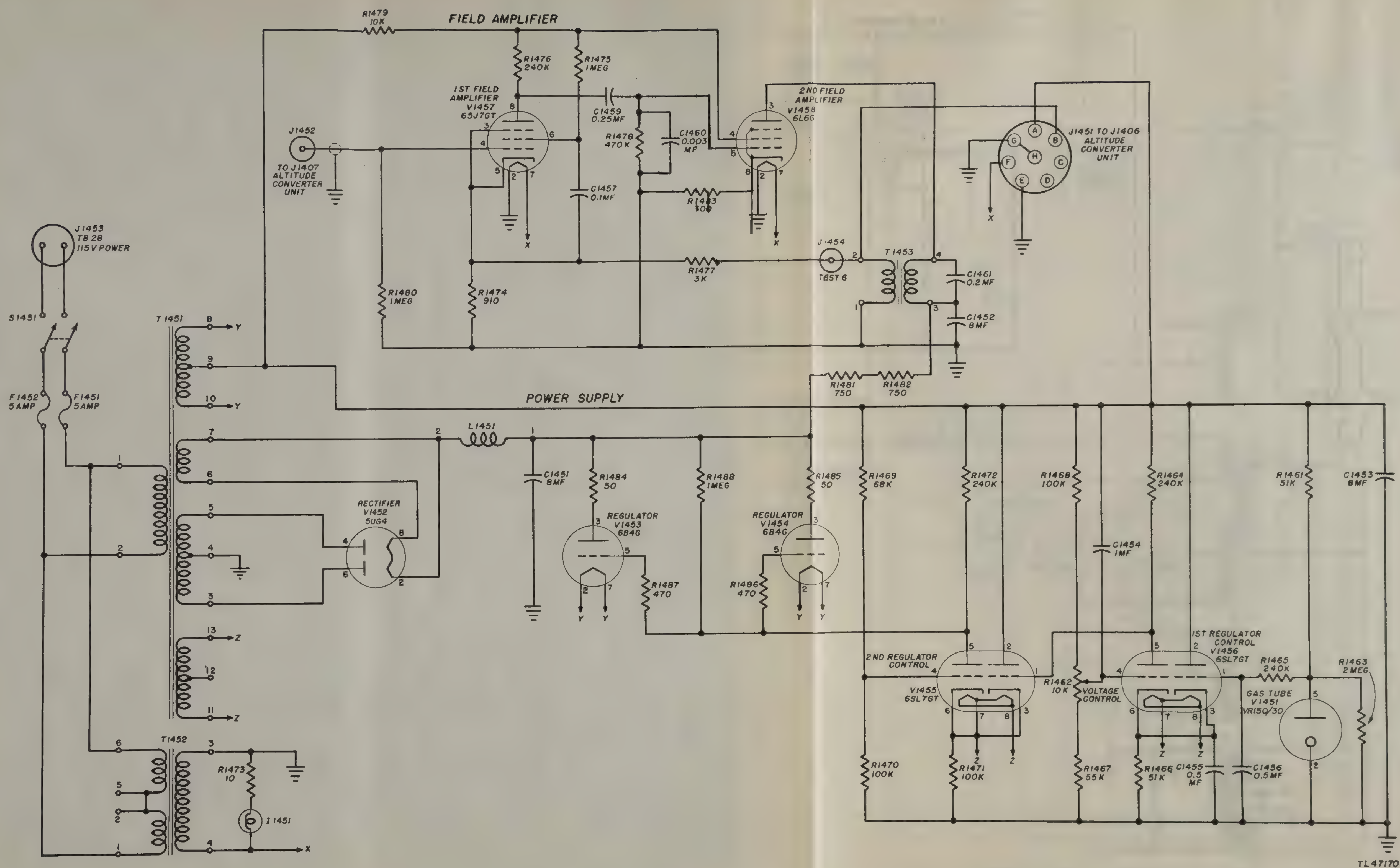


Figure 256. Altitude converter power supply, complete schematic diagram.

Figure 256. Altitude converter power supply, complete schematic diagram.

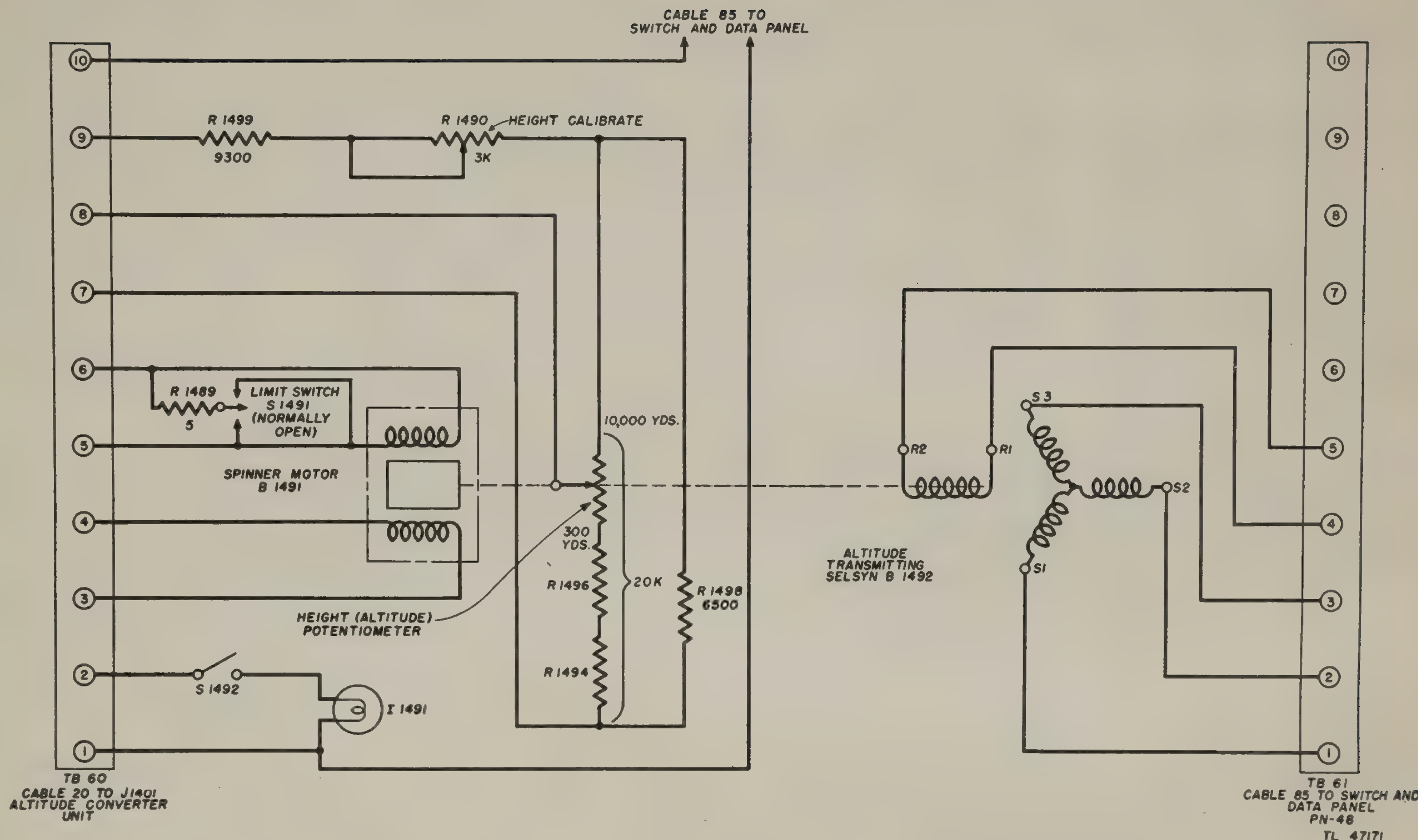


Figure 257. Altitude data unit, complete schematic diagram.

CHAPTER 9

COMPLETE BLOCK AND CONTROL DIAGRAMS

SECTION I

COMPLETE BLOCK DIAGRAM

202. PURPOSE.

The block diagram of Radio Set SCR-784 shown in figure 258 is a complete functional presentation of the electrical circuits of the set. It shows the relationship of the circuits discussed separately in the preceding chapters, and their function in the over-all operation of the set. The block diagram is ideal to use while making a quick review of the operation of the equipment, or when instructing others in the broad details of its performance. It also enables the trouble shooter to follow the course of a signal from circuit to circuit without having to bother with the detailed circuit tracing, necessary when schematics are used. Then, when trouble is suspected in an individual circuit, reference can be made easily to the proper schematic and trouble-shooting data to locate the source of trouble accurately.

203. READING THE DIAGRAM.

a. In figure 258 the various circuits of the equipment are represented by blocks marked with the name of the circuit. A chassis or major component is represented by a large block, and the circuits within the component are represented by smaller blocks. Interconnections have been simplified and are indicated by solid lines with arrow heads which show the direction in which the signal is progressing.

b. Where the signal is shown to leave a major component opposite one of the smaller blocks within it, it is indicated that the signal leaves the component from the circuit identified by the smaller block. Also, where the signal is shown to enter a major component opposite a smaller block, it is indicated that the signal is applied to the circuit represented by the smaller block.

c. The a-c distribution system has been omitted to simplify this block diagram. Filament connections and d-c connections within the various units have been omitted also for the same reason. These latter voltages are shown applied to the entire major component, and their distribution within the component is to be assumed. Inasmuch as the purpose of the diagram is to emphasize the functional, or signal-carrying connections, any other connections which might cause confusion and defeat the main purpose of the diagram have not been included.

204. REVIEW OF THEORY WITH BLOCK DIAGRAM.

a. General. Radio Set SCR-784, in common with other radar sets, has as its primary functions:

(*1*) The transmission of a short pulse of radio-frequency energy.

(*2*) The reception of echo signals caused by the reflection of this pulse of energy upon its striking an aircraft or other target.

(*3*) The measurement of the time interval between the transmission of the pulse and the reception of the echo.

(*4*) The presentation of this time factor as linear distance between the radar set and the target.

(*5*) In addition to these basic detection and ranging functions, Radio Set SCR-784 presents visual indications of the azimuth and elevation positions of the target based upon the position of the antenna when it is pointed accurately toward the target. It also provides electrical and mechanical data required by gun directors for the control of antiaircraft fire. The following summary of these actions, with reference to the block diagram (fig. 258) shows how the equipment operates.

b. Transmitting System.

(*1*) The components of the transmitting system are shown in the left hand column in the block diagram. They are the high-voltage rectifier, the driver unit, the modulator, and the transmitting oscillator, all located in the trans-

mitter frame assembly. The transmitting system is activated by a negative pulse of voltage from the range unit. This pulse enters the driver unit along the line marked trigger. The trigger frequency is 1,707 times a second. This causes the transmitting system to transmit a 0.8 microsecond r-f pulse of voltage 1,707 times per second and to remain inactive during the period between these trigger pulses.

(*2*) The trigger pulse is applied to the multivibrator in the driver unit. Each pulse causes the multivibrator to deliver one pulse of voltage which is amplified and inverted by the inverter and applied to the grids of the drivers, causing the drivers to produce a large pulse of positive voltage which is applied to the grids of the modulator keyer tubes. The delay line, shown in the driver unit, serves to determine accurately the width of the pulse applied to the grids of the keyer tubes. This is done by taking the output pulse of the driver unit at a point where it is negative and applying it through the delay line to the grid of the first driver tube. The characteristics of the delay line are such that the grids of the drivers receive a large negative pulse 0.8 microsecond after the keying pulse appears at the plates of the last driver. This clips the action of the positive pulse on the grid of the first driver, and limits the width of the keying pulse to approximately 0.8 microsecond. The keyers, in turn, apply a large negative pulse to the transmitting oscillator during this 0.8 microsecond period and the transmitting oscillator emits a pulse of r-f voltage which is delivered by the r-f line to the antenna. The damping diodes help to cut off the transmitting oscillator at the end of the pulse from the keyer thus sharpening the trailing edge of r-f pulse. The high-voltage rectifier supplies the high voltage (plus 22 kilovolts) applied to the transmitting oscillator through the plate circuit of the keying tubes. Separate rectifiers in the modulator furnish bias to the keying tubes and plate voltage for the last two driver tubes.

c. Radio-frequency System. The radio-frequency system is composed of the r-f line, the antenna and the T-R box. Included in the line are the rotating joints. These are not shown on the block diagram because their function is primarily mechanical. The r-f line accepts the pulse of r-f energy from the transmitting oscillator and conveys it to the antenna. The antenna radiates this r-f energy and receives the reflected r-f energy (echo) from the target. The T-R box acts as an electronic switch to disconnect the receiver from the r-f line while the transmitter is operating and to connect the receiver to the r-f line while the transmitter is not operating.

d. Receiving System.

(*1*) The receiving system is comprised of the components necessary to accept the incoming r-f echo signals from the T-R box and convert them into video signals for application to the scopes and for activating the automatic tracking system. The components of the receiving system are the crystal mixer, the local oscillator, the preamplifier, the receiver, the remote video amplifier, and the receiver power supply.

(*2*) The crystal mixer and local oscillator form a heterodyne conversion circuit which functions on the same principle as the conversion circuits of a standard superheterodyne receiver. This circuit converts the approximately 3,000-megacycle echo signal to an intermediate frequency of 30 megacycles and applies this 30-megacycle signal to the preamplifier where it is passed through two stages of i-f amplification and then applied to the receiver. In the receiver, the signal goes through three more stages of i-f amplification after which it is split into two channels. These are the range channel and the servo channel. The range channel provides an additional stage of amplification in the receiver and further amplification and detection in the remote video amplifier. The output of the remote video amplifier consists of the echo signals which appear on the range and PPI scopes, and the video input to the automatic range tracking unit. The servo channel contains two more stages of i-f amplification, a video detector, and two stages of video amplification. The output of the servo channel consists of the gated video echo signals which activate the automatic azimuth and elevation tracking equipment of the set. The gate pulse comes from either the range unit or ART unit depending on the setting of the ART-NORMAL switches. The output of the servo channel contains only the echo pip caused by the target which is being tracked, while the output of the range channel contains the pips of all targets in the antenna beam. Since the servo channel is operative only during the short period represented by the narrow gate, the target is at a distance approximately equal in time to the setting of the narrow gate delay in the range unit. The servo channel also develops the

AGC (automatic gain control) voltages required in the operation of the receiving system.

e. Range System.

(*1*) The range system is composed of the range scopes, the components providing the basic timing pulses which operate the equipment, and the necessary power supply and control circuits. All these components are located in the range unit, the range indicator unit, the automatic range tracking unit, the range unit power supply, and the automatic range tracking unit power supply.

(*2*) The 81.95-kc crystal oscillator is the basic timing circuit of the equipment. Part of its output is fed to the 2,000-yard sweep transformer to provide the circular sweep for the 2,000-yard range scope. Another part of its output is fed to the trigger generator which generates the trigger voltage used to time the transmitter, the PPI sweep, and the automatic range tracking unit. The 81.95-kc frequency is then stepped down by the 20-kc multivibrator and the 5-kc multivibrator to provide the circular sweep for the 32,000-yard scope. The 5-kc frequency is further reduced to secure the basic timing frequency of 1,707 cycles per second which is the basic recurrence frequency of the equipment. This 1,707-cycle frequency is used to trigger the narrow gate, wide gate, and trigger selector circuits. The trigger selector circuits select the proper pip of the 81.95-kc frequency to provide the trigger signal for the transmitting system, PPI, and automatic range tracking units.

(*a*) The output of the range unit consists of the following signals:

1. 2,000-yard sweep to the 2,000-yard scope.

2. 32,000-yard sweep to the 32,000-yard scope.

3. Wide gate to the 32,000-yard scope.

4. Narrow gate to the receiver and 2,000-yard scope.

5. Narrow gate to the PPI unit.

6. Trigger to the driver unit.

7. Trigger to the PPI unit.

8. Trigger to the automatic range tracking unit.

(*b*) The input consists of the operating voltages from the range power supply and the connection to the narrow gate delay potentiometer in the range indicator unit.

(*3*) The range indicator unit contains the 2,000- and 32,000-yard range scopes, the fine and coarse range transmitting selsyns, the range data potentiometer, the narrow gate delay potentiometer, the range motors, the range gear train, range servo drive system, and the oscillator phase shifter circuits of the automatic range tracking system. The action of the gear train is to position the hairlines on the plastic disk in front of the range scopes in accordance with a target on the 2,000- and 32,000-yard range scopes, to position the data transmitting units for transmission of accurate data, and to position the narrow gate delay potentiometer so that the narrow gate contains the target it is desired to track. With the switches back of the receiver, range indicator, and range unit set to the normal position and the range tracking switch set to MANUAL, the aided tracking handwheel rate control is fed to the servo drive circuit to control the rate motor. This allows the operator to make the hairline and narrow gate on the range scopes follow any desired target and at the same time gates the receiver to allow the automatic azimuth and elevation circuits to follow the selected target in the narrow gate.

(*4*) The automatic range tracking unit is only in the circuit when the switches back of the receiver, range indicator, and range unit are set to the ART position.

(*a*) With the range tracking switch in the AUTOMATIC position, the automatic range tracking circuits enable the set to track automatically and give continuous range data for a selected target. The input to the automatic range tracking circuits is a trigger voltage from the range unit to the input multivibrator. One output from the multivibrator triggers the 410-kc oscillator in the range indicator unit and produces a sine wave that is continually shifted in phase by means of the phase shifting capacitor which is mechanically connected to the range gearing. The other output triggers the saw-tooth delay circuit which generates a pulse whose leading edge is differentiated and triggers the illuminating and N^2 gate generators. The illuminating gate brightens the 2,000-yard range scope in the vicinity of the target and triggers the N^2 gate which is applied to both range scopes, the receiver, and the N^2 gate tracker circuit. The other input to the N^2 gate tracker circuit is the video input from the receiver. If the video signal and N^2 gate coincide, the position of the leading edge of the saw-tooth generator pulse and hence the N^2 gate remain the same. If they do not coincide, the

output of the N^2 gate tracker is such that it changes the position of the leading edge of the saw-tooth generator pulse and thus positions the N^2 gate to make it coincide with the video signal. In this way the N^2 gate coincides with the video signal in the receiver channel and on the range scopes. The N^2 gate and sine wave output from the phase shifting oscillator are applied to the servo tracker. As the N^2 gate moves, the output of the servo tracker is such that it supplies a voltage to the range servo drive to keep the hairline over the N^2 gate on the range scope. At the same time the phase of the sine wave oscillator is shifted so as to keep the N^2 gate and the sine wave in the servo tracker in the same relative position.

(*b*) With the range tracking switch in the manual position, the range servo drive system and range hairlines are moved in the same manner as when the ART-NORMAL switches are in the NORMAL position. In this case the video input to the N^2 tracker is replaced with an input from the sine wave oscillator. The relative phases of the N^2 gate and the sine wave oscillator again determine the position of the leading edge of the saw-tooth generator output. The N^2 gate can, therefore, be made to follow any target that appears on the range scope by means of the range handwheels.

(*5*) The range unit power supply provides the voltages necessary for operating the tubes in the range unit and the range indicator unit. It also contains the power supply which operates the rate motor and tachometer in the range indicator unit. The automatic range tracking unit power supply supplies the necessary regulated and unregulated operating voltages for the automatic range tracking unit. Each of these power supplies is contained in a separate chassis.

f. Plan Position (PPI) System.

(*1*) The plan position system, referred to as the PPI system, is the group of components which provide the PPI indications on the PPI scope. These are the PPI unit, the PPI indicator (scope), the PPI power supply, and the PPI selsyn located in the base of the pedestal.

(*2*) The PPI unit provides the basic sweep circuits for the PPI scope and also contains the signal mixer which applies the various signals to the elements of the PPI scope. The PPI sweep is generated in the PPI unit in the following manner: the trigger from the range unit is amplified and then used to lock the multivibrator which drives the saw-tooth sweep generator. The saw-tooth sweep is then amplified by the selsyn driver and applied to the rotor of the PPI selyn in the pedestal. Depending upon the position of the PPI selsyn rotor, three saw-tooth waves of different voltages are generated. These are applied to a special resistor circuit from which two voltages 90 degrees out-of-phase are obtained. These two voltages, when applied to the PPI horizontal and vertical deflections yoke, cause the sweep trace on the tube. The action of the PPI selsyn is such that, as the rotor of the selsyn rotates, the sweep rotates around the face of the scope. Thus the direction of the sweep line in azimuth is an indication of the direction in which the antenna is pointing. The intensifier circuit illuminates the trace only during the time that the sweep-forming dot is on its outward trip, and reduces the intensity of the spot on its return to the center of the tube so that only the outward sweep is visible.

(*3*) The range marker generator produces pips at time intervals representing 10,000 yards. These pips are produced along the sweep line so that the range of a signal may be estimated from them.

(*4*) The signal mixer circuit accepts the video signals from the remote video amplifier, the narrow gate signal from the range unit, and the range marker pips. It applies these signals to the grid of the PPI tube in such a manner that they appear as intensified portions of the sweep on the tube.

(*5*) The PPI indicator contains only the PPI scope tube, the horizontal and vertical deflection yoke, and the focusing yoke.

(*6*) The PPI power supply contains a regulated rectifier and an unregulated rectifier which provides operating voltages for the PPI unit. It also contains the high-voltage rectifier for the beam-forming element of the PPI tube.

g. Antenna Positioning System. The antenna positioning system consists of the components necessary to position the antenna in azimuth and elevation. These components are: the automatic tracking unit, azimuth and elevation tracking unit, the antenna position control unit, the indicator-control panel, the antenna position indicator unit, the azimuth and elevation motor generators, the field power supply, the azimuth and elevation drive motors, the spinner motor and reference generator connected to the antenna, and the azimuth and elevation selsyn transformers in the pedestal.

(*1*) *Automatic.* The main purpose of the

antenna positioning system of Radio Set SCR-784 is to provide automatic tracking. In automatic operation the antenna automatically positions itself on a target which appears in the narrow gate.

(*a*) The antenna is designed to make the antenna beam rotate around the axis of the reflector causing a modulation of the echo signals received from any target which is not located on the axis of the reflector but no modulation of the echo signals received from a target which is located directly on the reflector axis. By demodulating the echo signal an a-c voltage is obtained which is called an error signal. This error signal is compared with a reference voltage derived from the reference generator on the pedestal and the resultant output is amplified and applied to the antenna causing it to move, eliminating the error signal by positioning itself directly on the target.

(*b*) The entire operation of the antenna position system may, therefore, be described as an action which tends to eliminate the error signal. The error signal is obtained from the modulated video signals in the output of the servo channel of the receiver. These video signals are further detected and amplified in the automatic tracking unit and transformed into a push-pull signal by the balanced amplifier and fed to the azimuth and elevation commutator tubes in the azimuth and elevation tracking unit. The azimuth and elevation commutator tubes and the azimuth and elevation squarer tubes in this unit compare the error signal with the azimuth and elevation reference voltages and develop d-c control voltages. The d-c control voltages are applied to the antenna to move it in the direction which will position the antenna on the target and eliminate the error signal.

(*c*) The d-c control voltages derived from the commutator tube circuits are applied to d-c amplifiers which in turn apply them to the azimuth and elevation motor generators. These motor generators amplify the small voltages applied to them and provide operating potentials for the armatures of the antenna drive motors. Field current for the antenna drive motors is provided by the field power supply. The torque limiting circuits are included in the azimuth and elevation tracking unit to prevent overdriving the antenna drive motors. The antihunt circuits introduce negative feedback into the system to prevent hunting of the antenna. In automatic operation, the selsyn transformers in the pedestal and the follow-up motors control the rotation of the selsyns in the antenna position control unit so that there will not be any position difference between them, and the antenna will not slew when the operation is changed from automatic to manual. The coarse selsyns in the pedestal serve to position the local dials of the antenna position indicator unit, and the fine and coarse selsyns both serve to transmit data to the gun director.

(*2*) *Manual.* In manual operation the antenna is positioned by the operation of two handwheels on the antenna position control unit. Manual operation is similar to automatic operation except that a 60-cycle reference voltage from the 60-cycle supply is used instead of the reference voltage from the reference generator. A 60-cycle error signal, which is the manual tracking error signal, is derived from the difference in position between the control selsyns in the antenna position control unit and the selsyn transformers in the pedestal. The antenna moves in such a direction as to make this voltage zero. The automatic tracking unit is not used in manual operation and the reference and manual tracking signals are applied directly to the commutator and squarer tubes in the azimuth and elevation tracking unit. The balance of the positioning operations are the same as for automatic operation.

(*3*) *PPI Scan.* In PPI scan operation the antenna is continuously rotated in azimuth and moved up and down in elevation by the operation of a motor gear-and-cam assembly in the antenna position control unit. PPI scan operation is similar to manual operation except that a drive motor and cam in the antenna position control unit drives the control selsyns instead of manual rotation of the control selsyns by the operator. The elevation selsyn may be disengaged to operate manually.

(*4*) *Remote.* In remote operation the antenna is positioned by the gun director from a remote location. During remote operation, two selsyns in the gun director are switched into the circuit in place of the two control selsyns in the antenna position control unit. Operation of the tracking head of the gun director moves the antenna of the SCR-784 correspondingly.

h. Data Transmission System. The data transmission system is composed of the units which transmit data to the gun director. This system includes seven data transmitting selsyns and three data transmitting potentiometers.

(*1*) *Selsyn Data.*

(*a*) The coarse and fine azimuth and elevation selsyns in the pedestal, and the altitude selsyn in the altitude data unit are used to transmit selsyn data to the M4, M7, or a similar type gun director. (The coarse and fine range selsyns in the range indicator unit are in the system but not used.) This data is transmitted by connecting these transmitting selsyns with corresponding receiving selsyns at the gun director. The receiving selsyns at the director then take on a position similar to the position of the data transmitting selsyns of the SCR-784. The coarse and fine azimuth and elevation selsyns are geared to the azimuth and elevation drives in the pedestal, and consequently transmit the position of the antenna at any given instant.

(*b*) The altitude selsyn transmits data derived from the altitude converter system. The altitude converter system consists of the altitude converter, the altitude converter power supply, and the altitude data unit. These components produce a measurement of the height of the target from the slant range and elevation angle information. Voltage is applied to the range potentiometer by the 250-cycle oscillator in the altitude converter and a 250-cycle voltage ($-D_0$) is obtained from the potentiometer which is proportional to the slant range of the target. This voltage is applied across the elevation potentiometer and a voltage (H_0) is derived which is a function of the sine of the elevation angle. This voltage is applied to the input of the summing amplifier. Also applied to the input of the summing amplifier is a voltage 180 degrees out-of-phase with the output of the elevation potentiometer. This out-of-phase voltage is derived from the height potentiometer in the altitude data unit. When the amplitudes of these voltages are not equal, a voltage is applied to one field of the two-phase altitude motor in the altitude data unit. The phase of this voltage is the phase of the larger of the two input voltages to the summing amplifier. The other field of the motor is supplied with a voltage 90 degrees out-of-phase with the output of the summing amplifier. This voltage is supplied by the phase shifter in the altitude converter and the field amplifier in the altitude converter power supply. The altitude motor will run when there is an output of the summing amplifier and it will run in a direction depending upon the phase of this output. The motor will continue to run until the two inputs to the summing amplifier are equal. Then there will be no output from the summing amplifier, and the altitude motor will stop. The altitude motor drives the altitude selsyn and the height potentiometer arm so that the position of the height potentiometer arm is transmitted by the altitude selsyn and represents the height (altitude) of the target.

(*c*) Since the altitude data unit is not accessible, the output of the height potentiometer is also applied to an altimeter through rectifying diodes and an altimeter bridge. This voltage is proportional to the altitude of the target and can be read on a calibrated meter.

(*2*) *Potentiometer Data.* The data transmission system includes three data transmitting potentiometers: the range potentiometer (which is driven by the gear train in the range indicator unit), the elevation azimuth potentiometers (both of which are geared to the antenna).

(*a*) The slant range potentiometer is a linear potentiometer which provides a voltage ($-D_0$) proportional to the slant range of the target. This voltage is transmitted to the gun director and is also applied to the elevation potentiometer ($-D_0$, $+ D_0$).

(*b*) The elevation potentiometer has two resistance cards, an altitude (sine) card and a horizontal range (cosine) card. Two voltages are derived from the elevation potentiometer which are proportional to the altitude of the target (H_0) and to the horizontal range of the target ($-R_0$). These voltages are transmitted to the gun director through the data panel.

(*c*) The voltage corresponding to the horizontal range (R_0 and $-R_0$) is also applied across the azimuth potentiometer which is a 360-degree potentiometer with two arms. The azimuth potentiometer produces two voltages (X_0 and Y_0) which serve to locate the direction of the target with reference to the X (east-west) and Y (north-south) coordinates of the position of the target in the horizontal reference plane. These two voltages are transmitted to the gun director through the data panel.

(*3*) All data, except that visibly presented in the SCR-784, is transmitted to the gun director through cables connected to the switch and data panel on SCR-784. These cables also supply the exciting voltages from the director for the data transmission system; and when in remote operation, the selsyn data from the director necessary to position the remote receiving selsyns and the remote dials in the antenna position indicator unit.

SECTION II

INTERUNIT DIAGRAMS

205. INTERCONNECTION CABLES WIRING DIAGRAM.

The interconnection cable diagram shown in figure 259 shows all the cables between the various units and components of the set. The wiring within the units is not shown on this diagram. All cable numbers and connection numbers are given except the connection numbers within the switch and data panel. All cable connections in the switch and data panel are shown in figure 260. A chassis or major component is represented by a dotted line box and all cable connections to that component are shown. Interconnections have been simplified and cables are represented by a single solid line. The cable itself may contain few or many conductors but each conductor is not shown, only the cable as a whole. The cable number is given on each end of the cable so that its connection between two components is easily recognized. In addition to the cabling between components, the wiring of the trailer lights, receptacles, and blowers is shown. This diagram is helpful in trouble shooting as a quick reference in tracing the connections from a certain jack of a component to another component. For example, if it is desired to know the input to jack J1003 of the receiver power supply, reference to this diagram shows it is through cable 94 from terminals 2 and 4 of terminal board TB38 on the rear of the left rack, through cable 89 from terminals 2 and 4 of terminal board TB29 on the rear of the right rack, through cable 88 from the switch and data panel. Reference to figure 260 or 261 will give the connections within the switch and data panel. Thus the input to jack J1003 may be traced to its source.

206. CONTROL CIRCUITS SCHEMATIC DIAGRAM.

A complete schematic diagram of the control circuits is shown in figure 260. This diagram shows the a-c input to jack J1906 on the switch and data panel and the detailed distribution to the control circuits. Each complete control circuit is shown with the details of the jack and plug pin numbers and components through which the circuit passes. The circuit components are shown in the chassis or unit in which the component is located. All the circuits within a certain unit are grouped together and inclosed with dotted lines to designate the unit. The diagram shows the relationship of the various control circuits and enables the trouble shooter to trace a circuit to test it at various points, and to locate and isolate trouble quickly in a control circuit. Where a circuit is shown leaving a unit and going to a unit not shown on this diagram, the unit it goes to is named and the circuit may be traced further by referring to the schematic diagram of that unit. Inasmuch as the purpose of this diagram is to emphasize the control circuit connections, the signal-carrying circuit connections and other connections which might cause confusion and defeat the main purpose of the diagram have not been included. The terminal board, jack, or plug pin number is shown. Adjacent to each connection of the line leading from it to another connection is shown the connection number to which the line goes. Thus, it is not necessary to actually trace out a line to follow a circuit, but only follow the connection numbers given. For example, jack J1906 is the input of the three-phase power to the switch and data panel and to the set. Opposite terminal A of J1906 is the connection number S1901-1, which means this line goes to terminal 1 on switch S1901. Locating switch S1901, we now find that opposite terminal 1 is the connection number J1906A, which shows that is the line from terminal A of jack J1906. When switch S1901 closes we see that terminal 1 closes to terminal 4 and opposite terminal 4 is the connection number T1978-X1. This means that the connection from terminal 4 is to terminal X1 on transformer T1978 of the voltage regulator. Referring to transformer T1978 in the voltage regulator we find opposite terminal X1 the connection number S1901-4, indicating that the connection is to terminal 4 on switch S1901. Each connection point on this diagram gives the number of the point or points to which it connects and a circuit is followed by its connection point numbers.

207. A-C POWER DISTRIBUTION SCHEMATIC DIAGRAM.

A simplified schematic diagram of the a-c power distribution of Radio Set SCR-784 is shown in figure 261. This diagram shows the three-phase a-c power input from the power

unit or a commercial source and the distribution of the separate phases to the various components of the set. Included on the diagram are numbers of the pins of the plugs, jacks, and terminal boards where connections are made, and the numbers of the cables between components. Interconnections have been simplified so that only the terminals and connections of the circuit concerned are shown in that circuit. Where a circuit is shown terminating at a jack, plug, or terminal board of a component or rack, its distribution within that component may be followed by referring to the schematic diagram of the component concerned. The line voltage switch, line voltage meter, and phase selector switch are on the indicator-control panel (shown within the dotted-line box). The voltage regulator, azimuth servo generator, elevation servo generator, heater contactor, and blower contactor are separate units. All the other switches and all the fuses shown are on the switch and data panel.

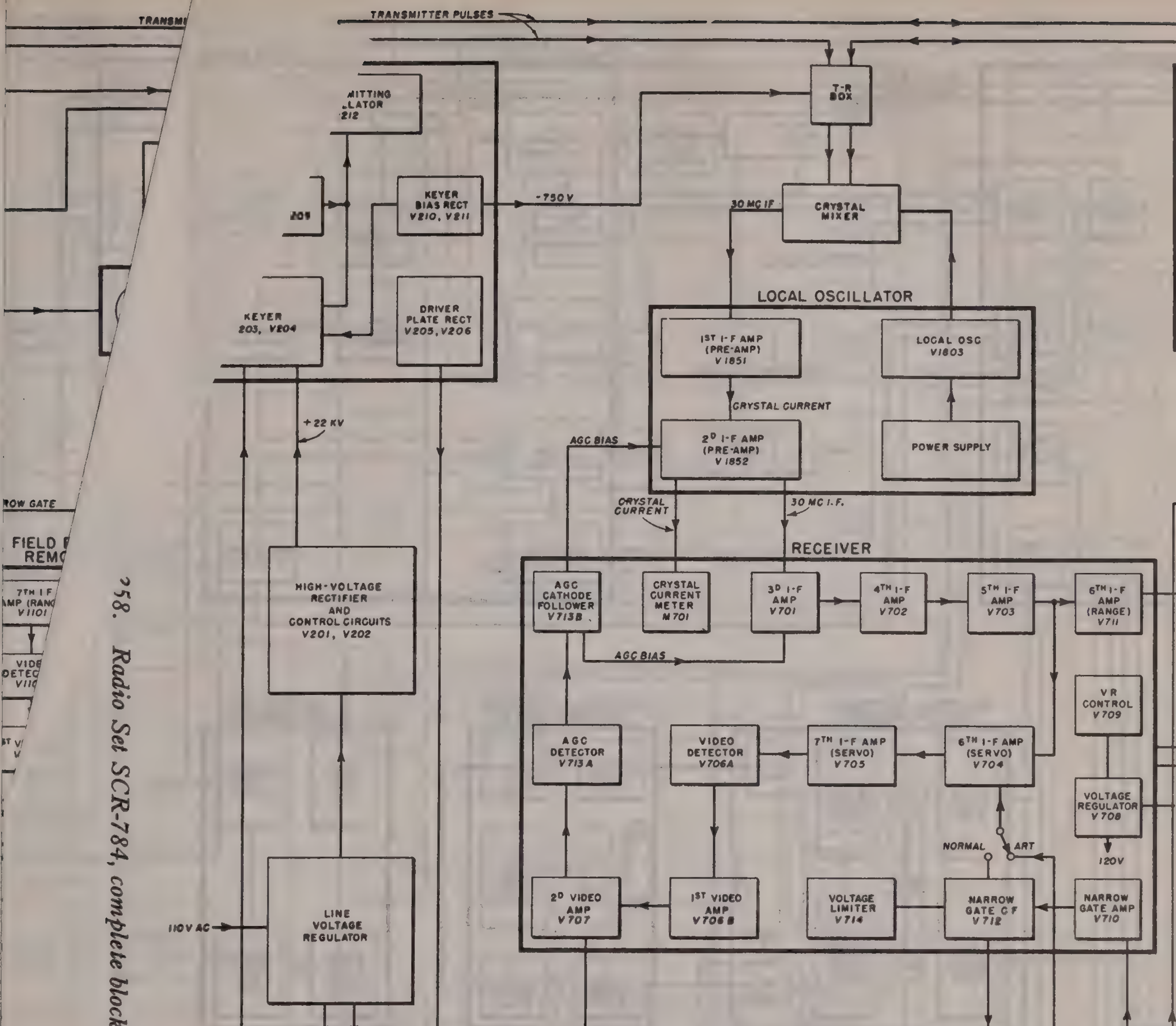
a. Power for the trailer lights and receptacles is taken off before the main line switch and is fused by fuses F910 and F911. Power for the dehydrator is supplied ahead of the main line switch so that this unit may operate when the set is turned off.

b. After passing through the main line switch, the voltage input to the set is regulated by the voltage regulator and supplied to terminal boards TB47-1, TB47-2, and TB47-3 for distribution to the high-voltage rectifier, the fused circuits, the spinner motor and the servo generators. From the voltage regulator a circuit is also supplied to the indicator-control panel line-voltage switch for raising or lowering the regulated a-c voltage to the set. With the voltage regulator set to its minimum position the voltage at X_2 of transformers T1977 and T1978 is the same as at X_1 since the voltage across the primary of these transformers is zero. As the voltage is raised, the variable taps move away from the center tap of transformer T1976 and a proportional voltage is applied to the secondaries of T1977 and T1978. This voltage adds to the voltage at X_1 and a corresponding greater voltage output is obtained from terminals X_2. Switches S1976 and S1977 are limit switches which remove power from the motor when the voltage reaches its maximum or minimum value.

c. Through the nine main protection fuses power is fed to the IFF equipment, the power supplies in the right and left racks, and the control circuits of the set. The voltage between any two phases can be measured by the line-voltage meter M1751 with the proper positioning of the phase selector switch S1755 on the indicator-control panel.

d. Three-phase power is supplied to the azimuth and elevation servo generators through the azimuth and elevation motor switches on the switch and data panel, and to the spinner motor on the pedestal through the spinner motor switch on the switch and data panel and through slip rings 30, 32, and 34.

e. This simplified diagram is intended to show only the distribution of a-c power. Any other connections which might cause confusion or defeat the main purpose of the diagram have not been included.



258. *Radio Set SCR-784, complete block diagram.*

unit or a commercial source and the distribution of the separate phases to the various components of the set. Included on the diagram are numbers of the pins of the plugs, jacks, and terminal boards where connections are made, and the numbers of the cables between components. Interconnections have been simplified so that only the terminals and connections of the circuit concerned are shown in that circuit. Where a circuit is shown terminating at a jack, plug, or terminal board of a component or rack, its distribution within that component may be followed by referring to the schematic diagram of the component concerned. The line voltage switch, line voltage meter, and phase selector switch are on the indicator-control panel (shown within the dotted-line box). The voltage regulator, azimuth servo generator, elevation servo generator, heater contactor, and blower contactor are separate units. All the other switches and all the fuses shown are on the switch and data panel.

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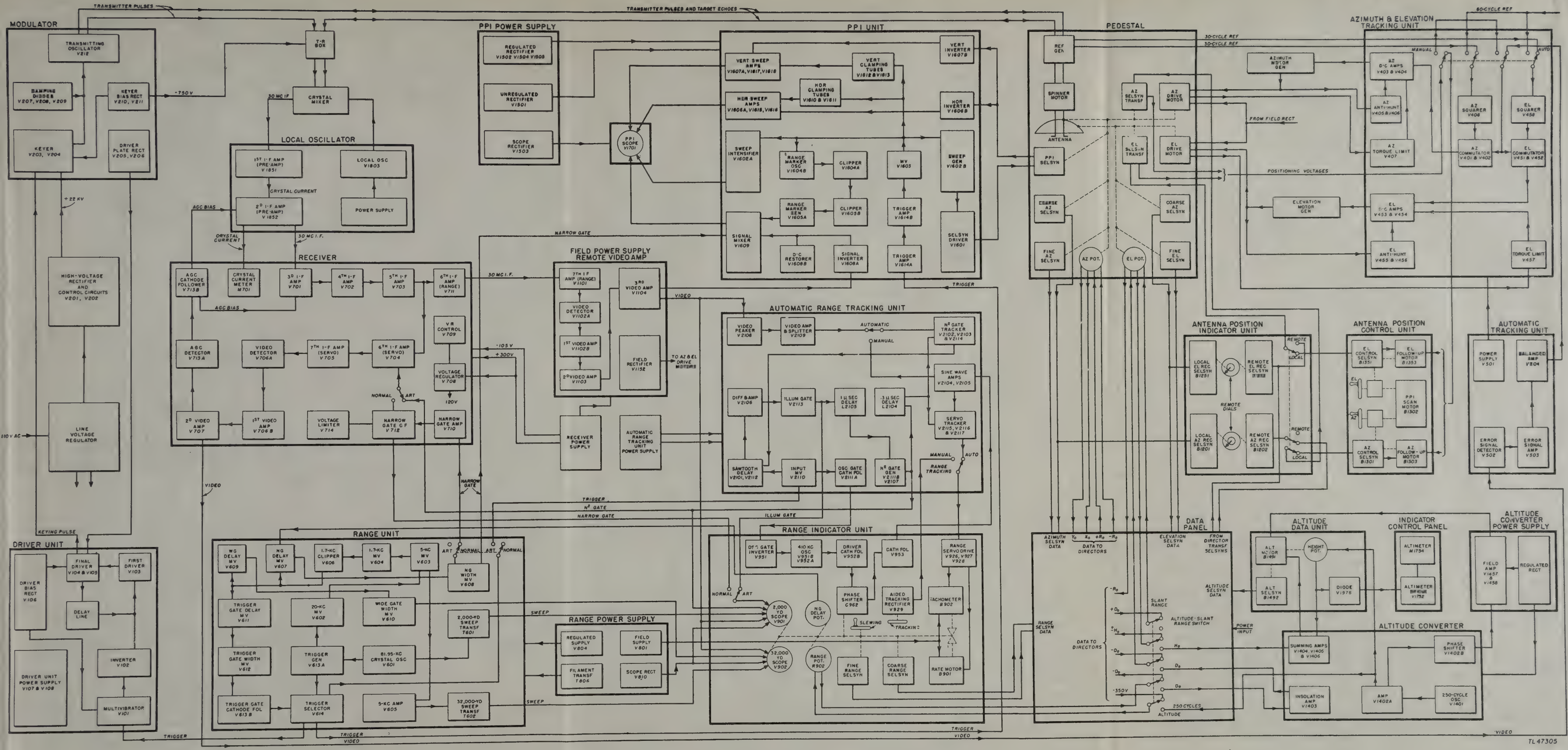

Figure 258. Radio Set SCR-784, complete block diagram.

Figure 258. Radio Set SCR-784, complete block diagram.

Figure 258. Radio Set SCR-784, complete block diagram.

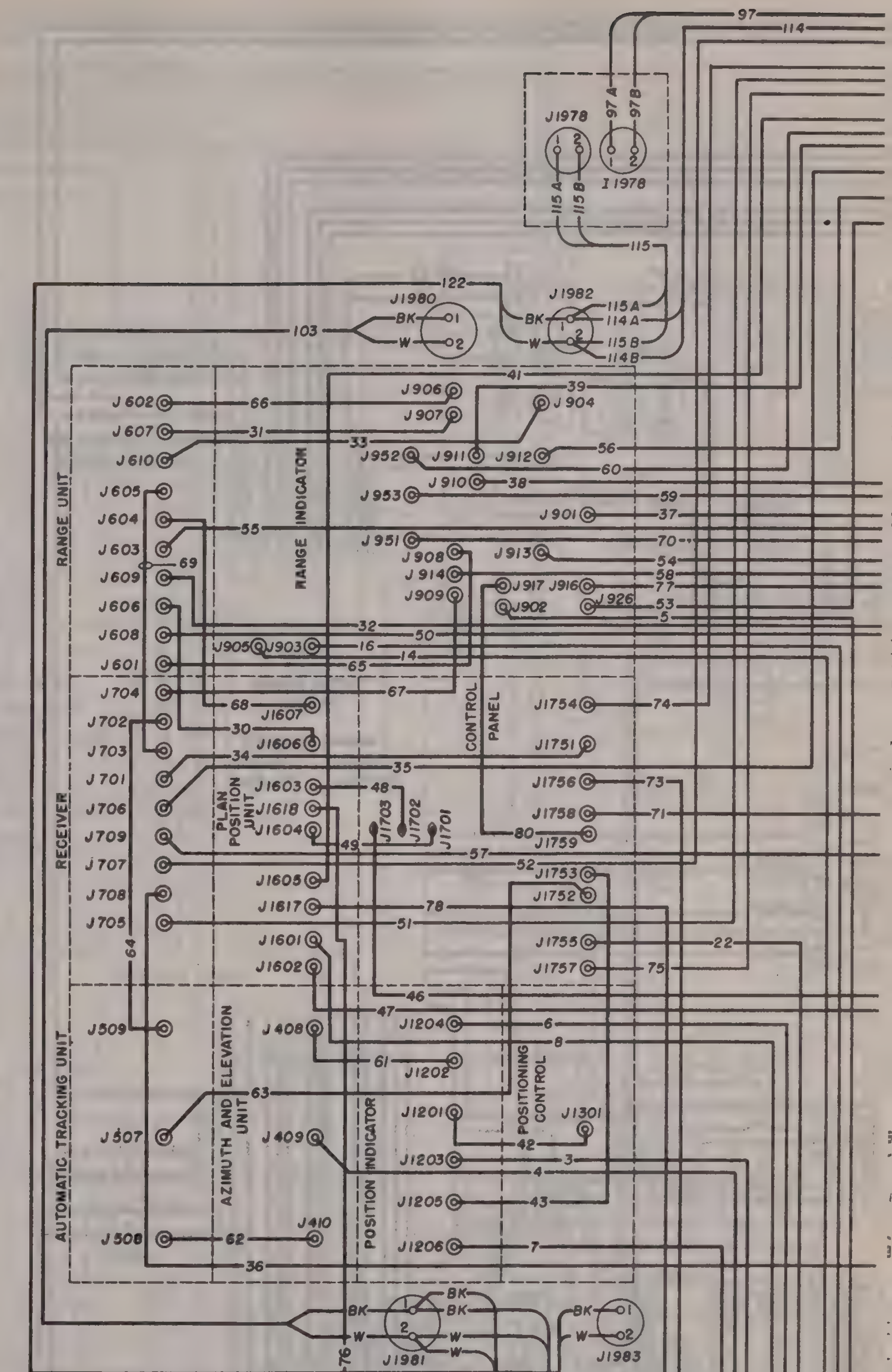

Figure 259. Interconnecting cables, wiring diagram.

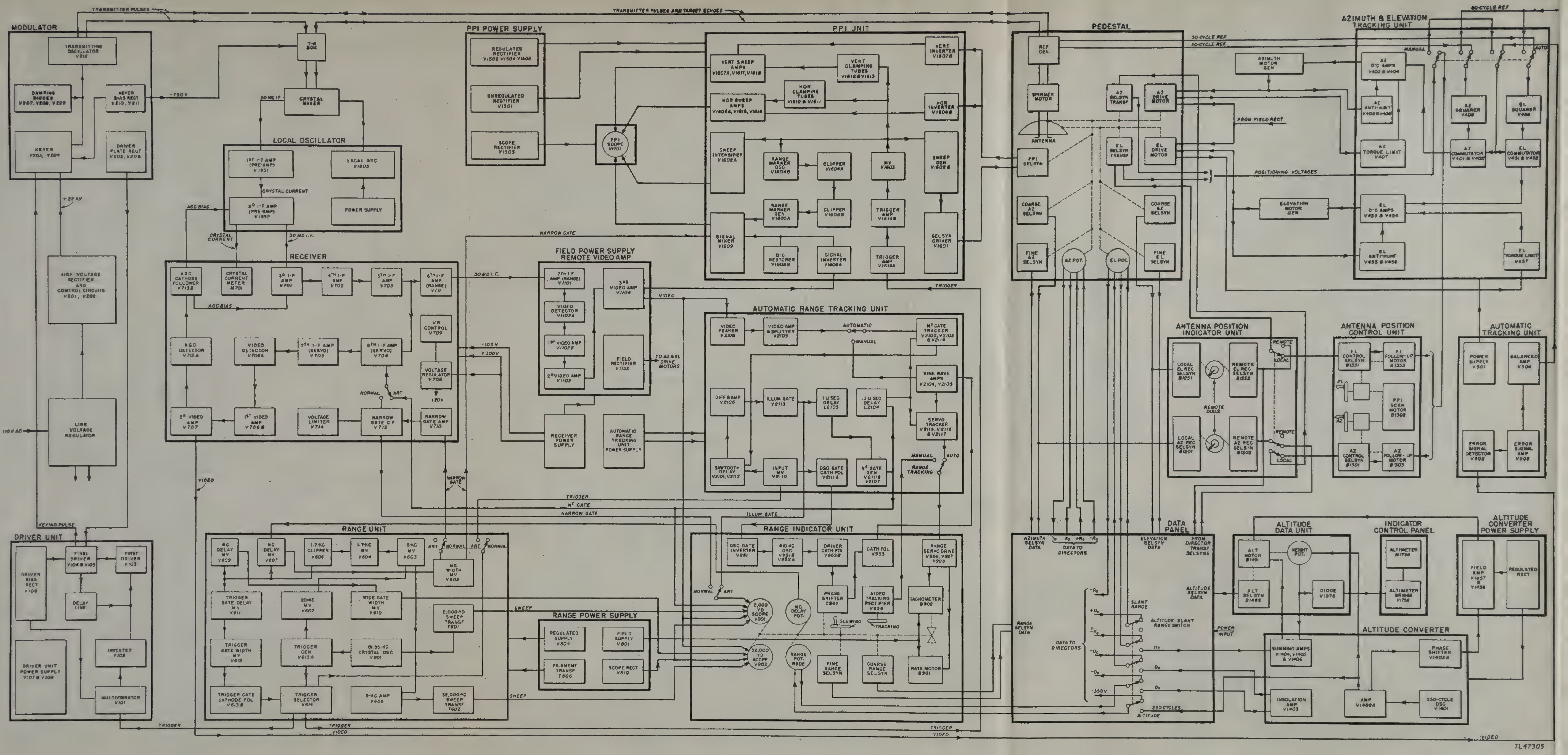

Figure 258. Radio Set SCR-784, complete block diagram.

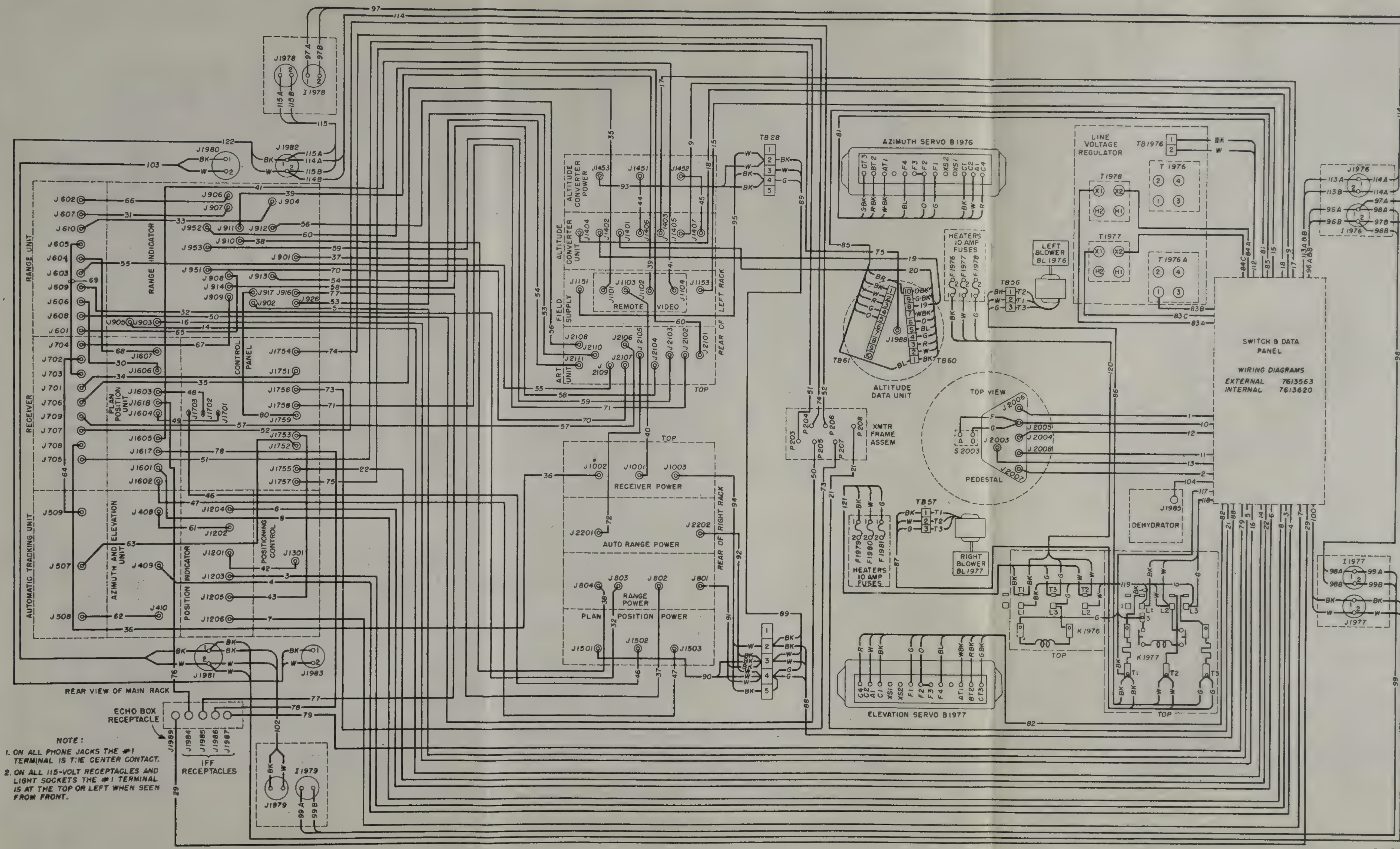

Figure 259. Interconnecting cables, wiring diagram.

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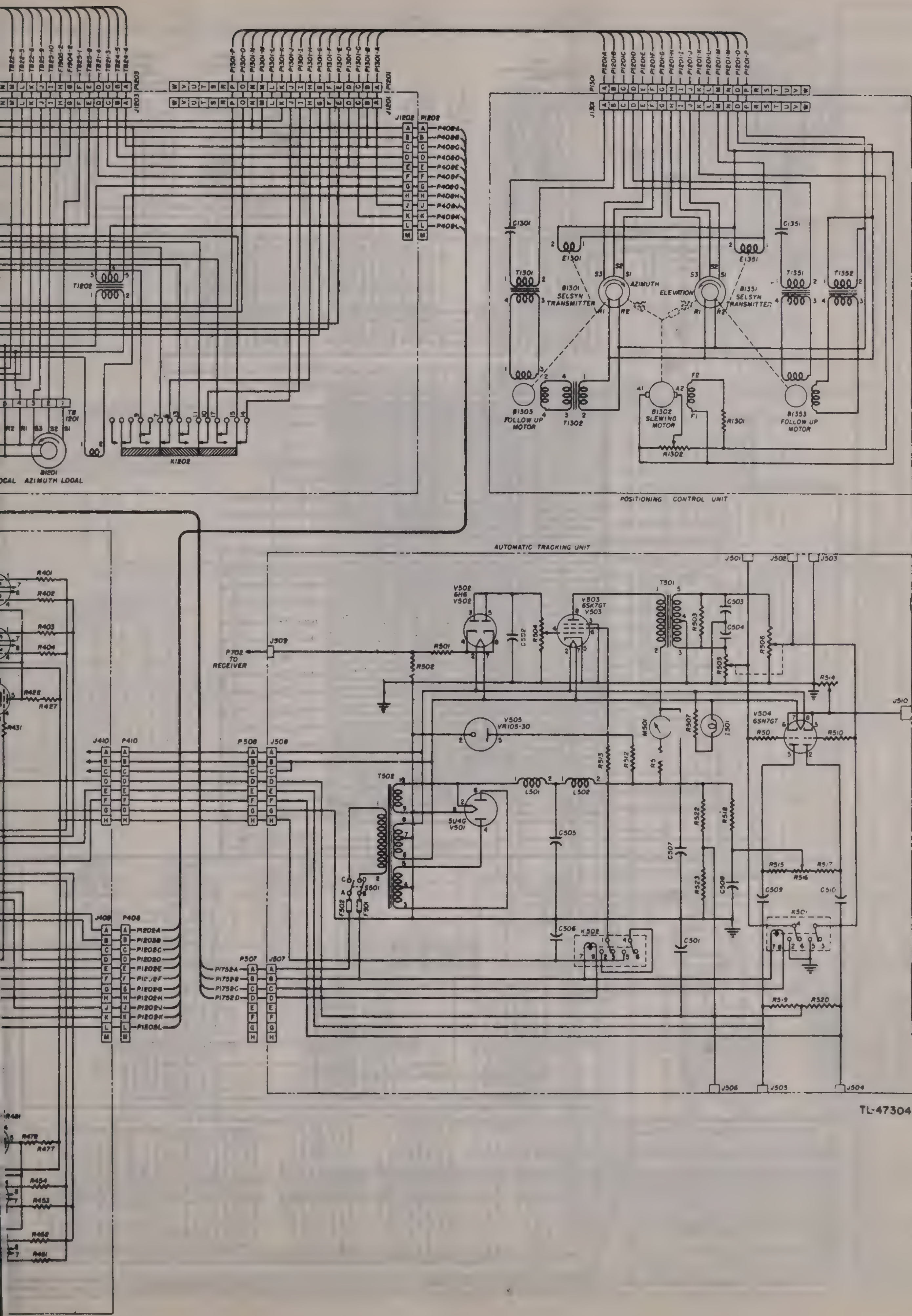

Figure 260. Control circuits, schematic diagrams.

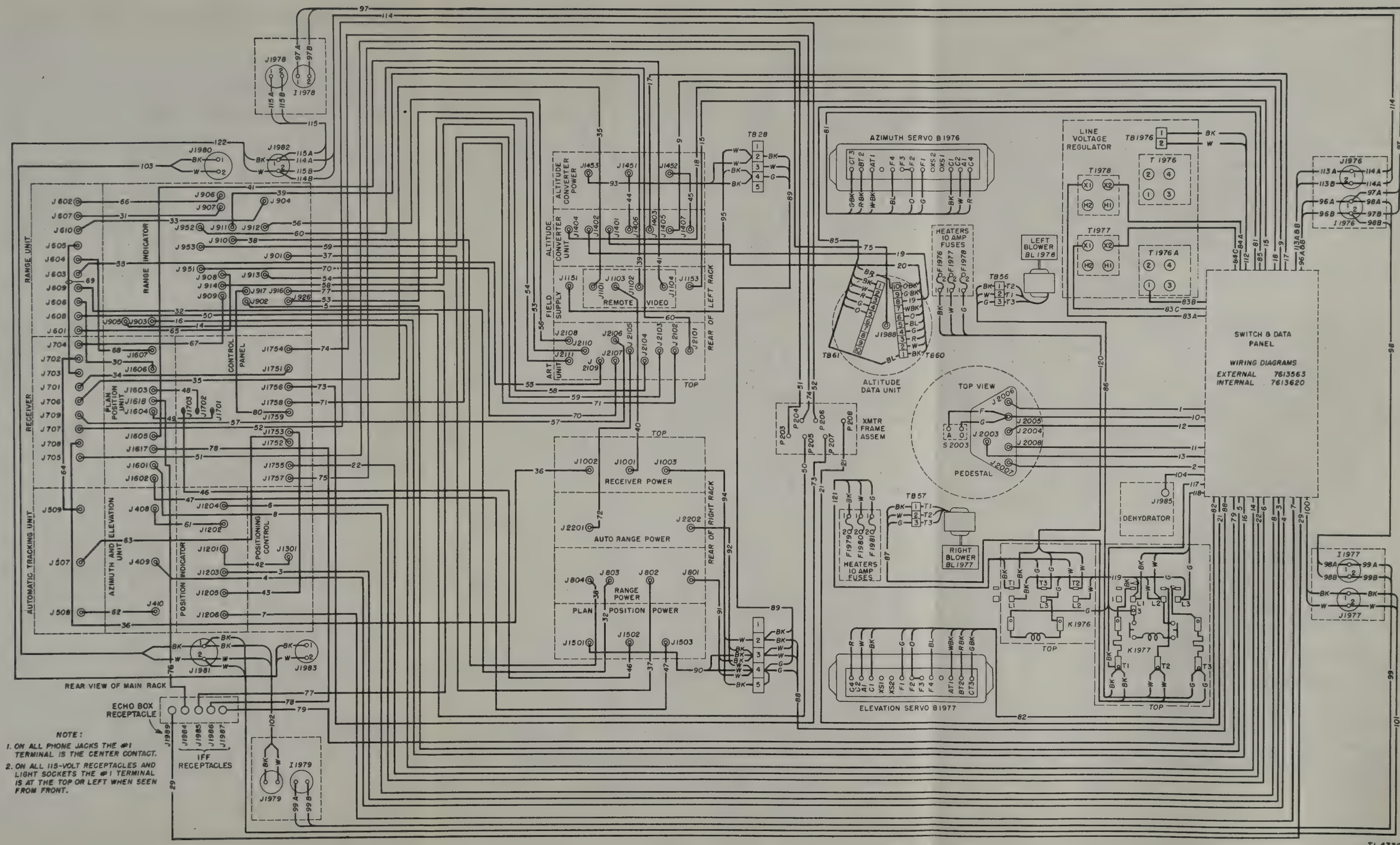

Figure 250. Interconnecting cables, wiring diagram.

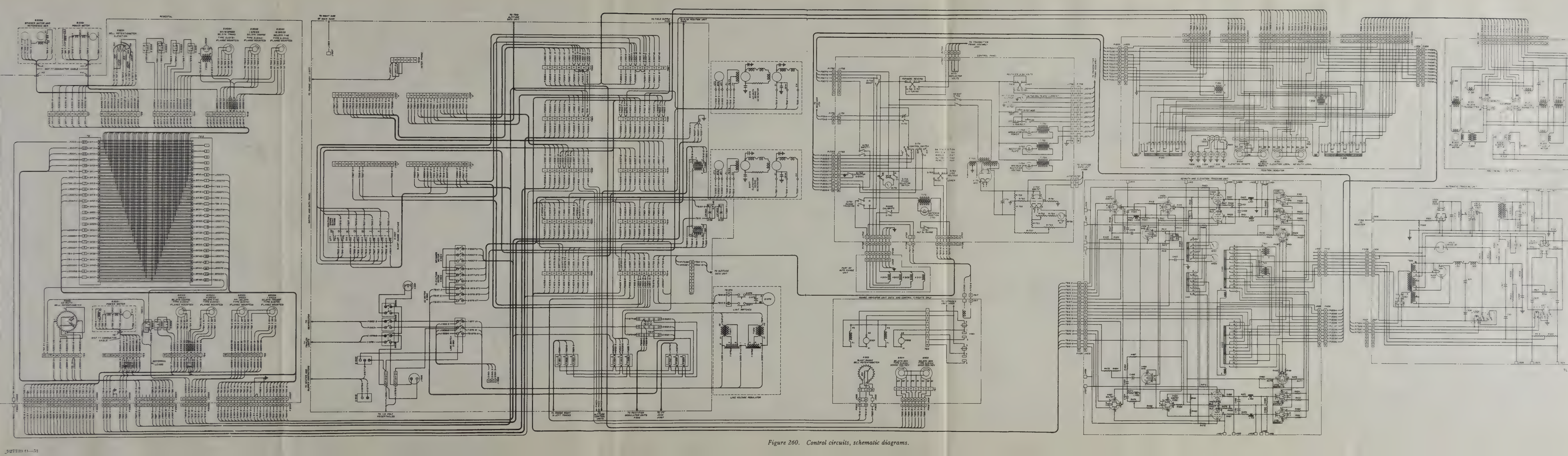

Figure 260. Control circuits, schematic diagrams.

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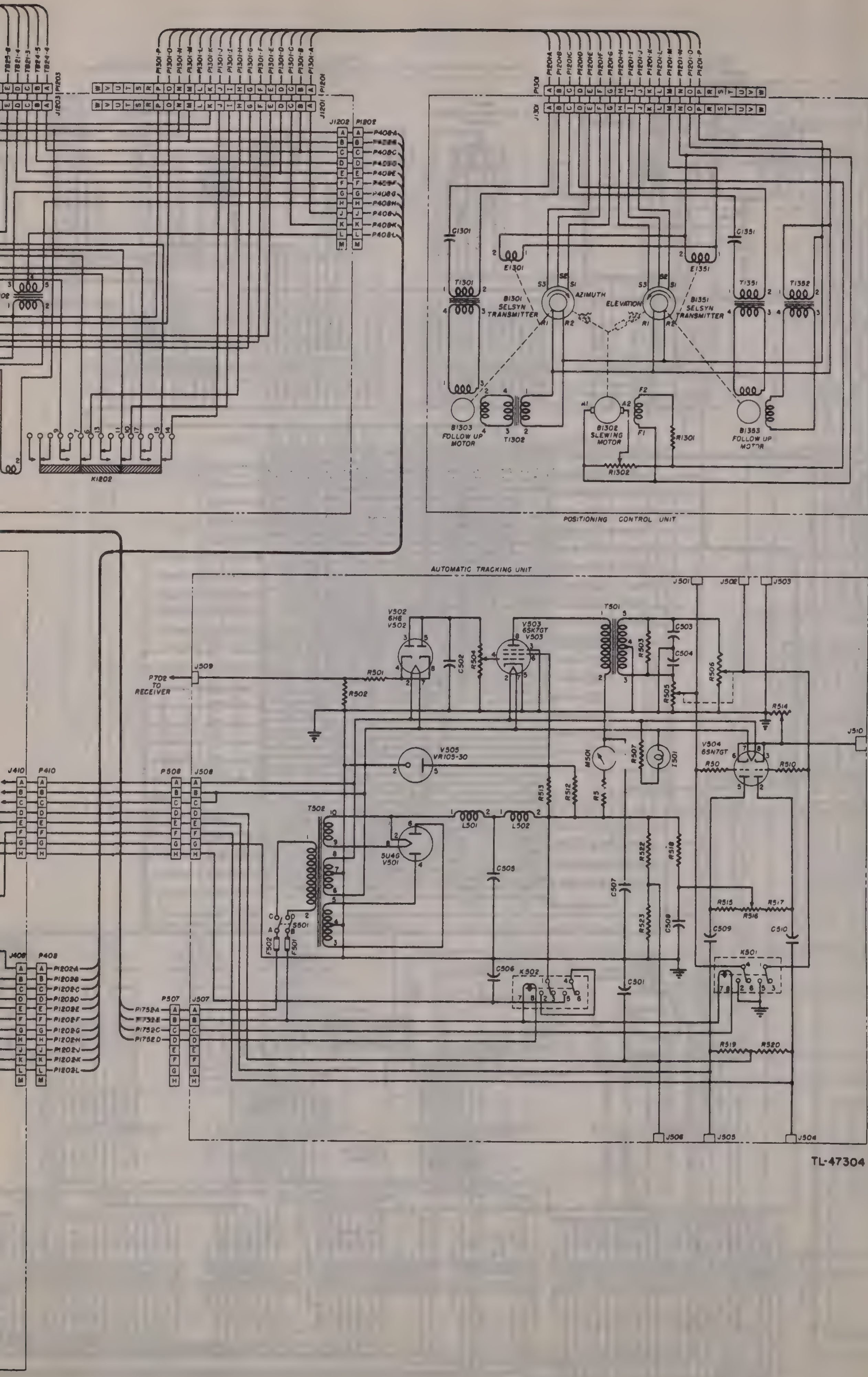
POSITIONING CONTROL UNIT
AUTOMATIC TRACKING UNIT
B1301 SELSYN TRANSMITTER
AZIMUTH
ELEVATION
B1351 SELSYN TRANSMITTER
B1303 FOLLOW UP MOTOR
B1302 SLEWING MOTOR
B1353 FOLLOW UP MOTOR
T1301
T1302
T1351
T1352
E1301
E1351
C1301
C1351
R1301
R1302
K1202
J1202
P1202
J1203
P1203
J1201
P1201
J1301
P1301
P702 TO RECEIVER
J509
J510
J501
J502
J503
J504
J505
J506
V502 6H6
V503 6SK7GT
V505 VR105-30
V504 6SN7GT
5U4G V501
T501
T502
L501
L502
M501
I501
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TL-47304

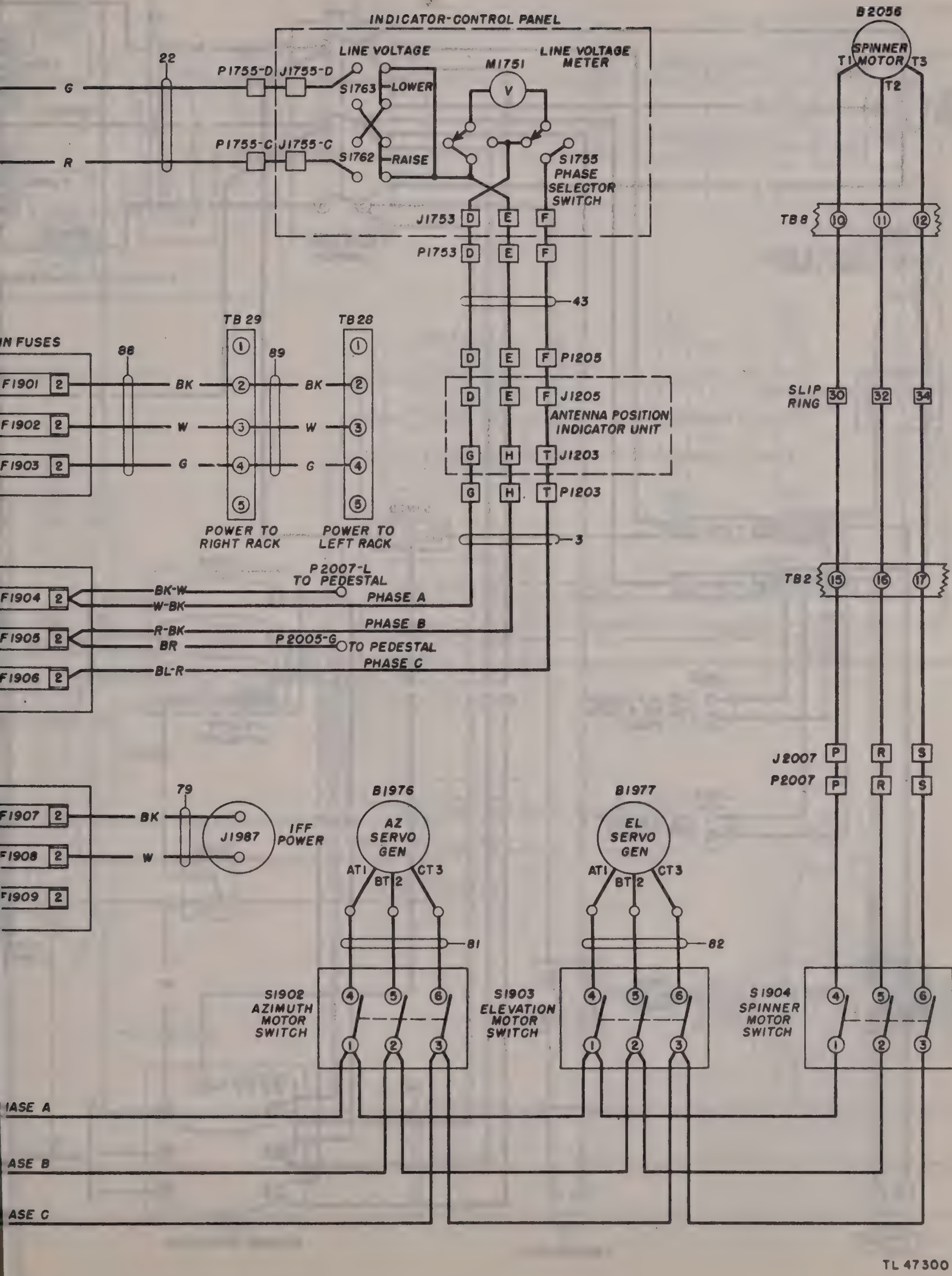

Figure 261. A-c power distribution, schematic diagram.

gram.

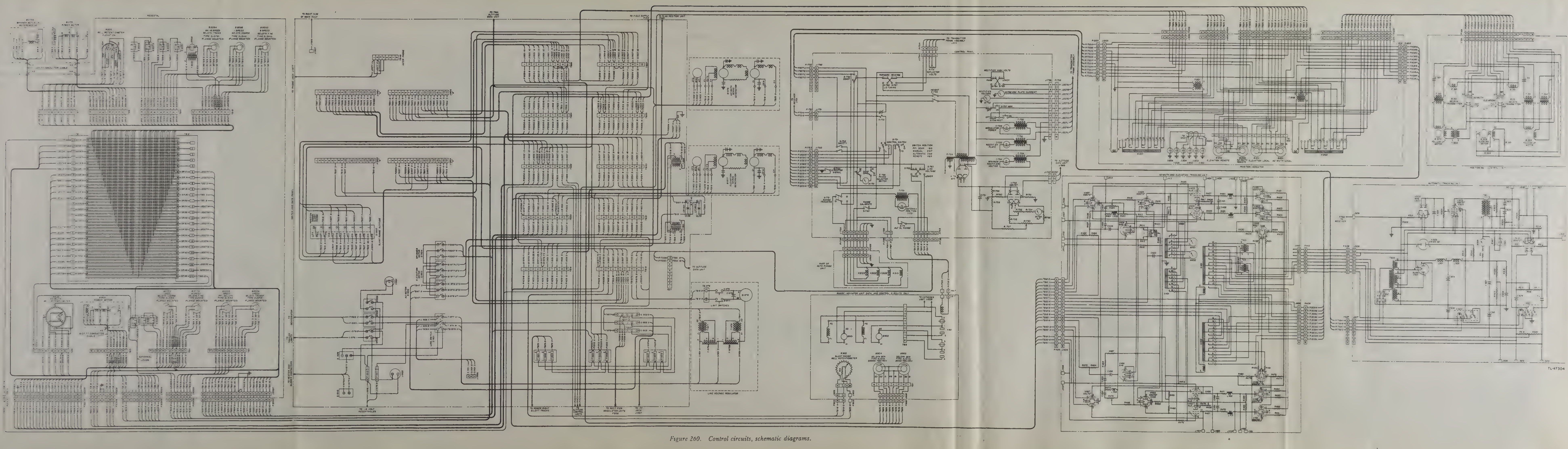

Figure 260. Control circuits, schematic diagrams.

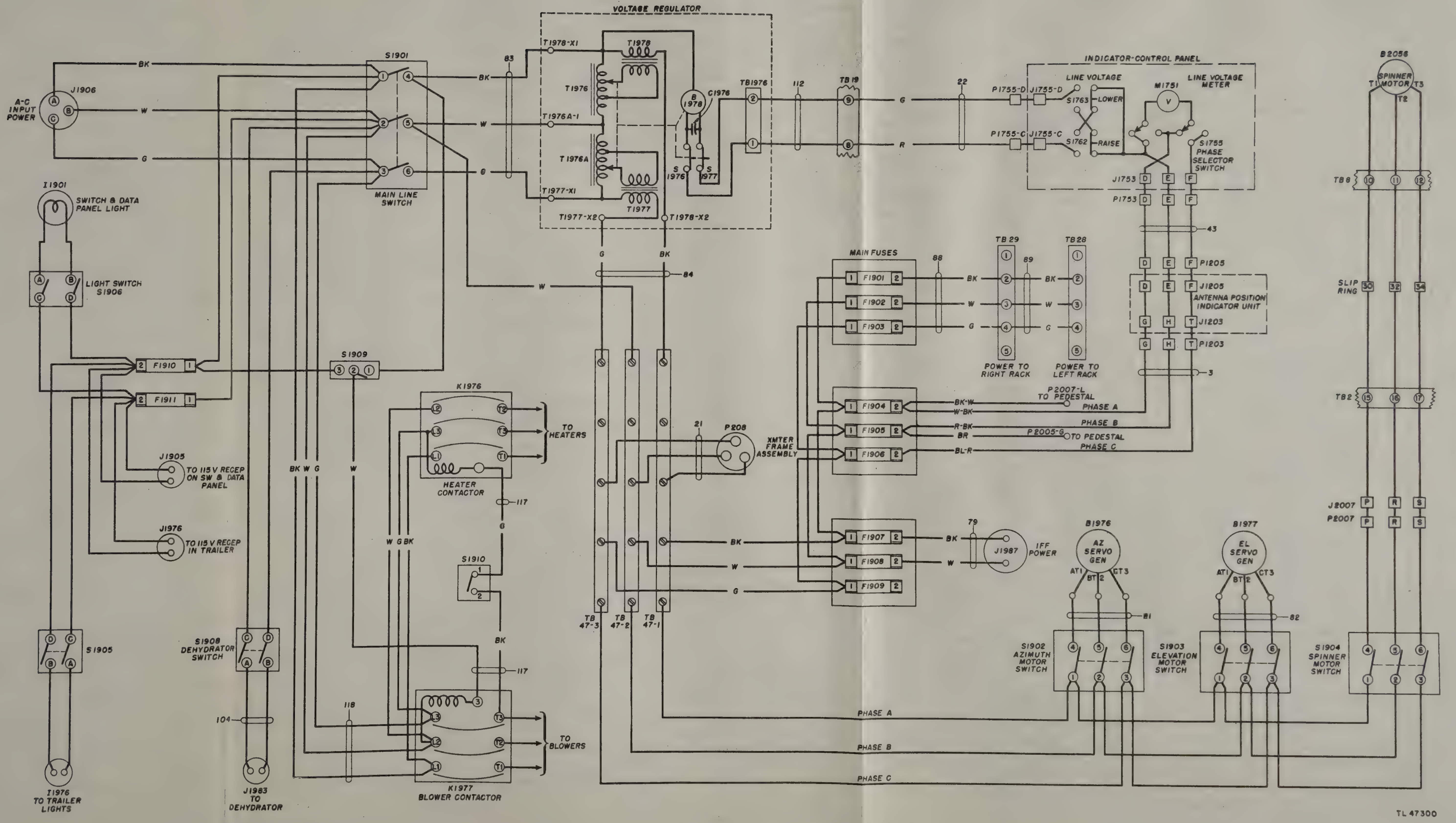

Figure 261. A-c power distribution, schematic diagram.

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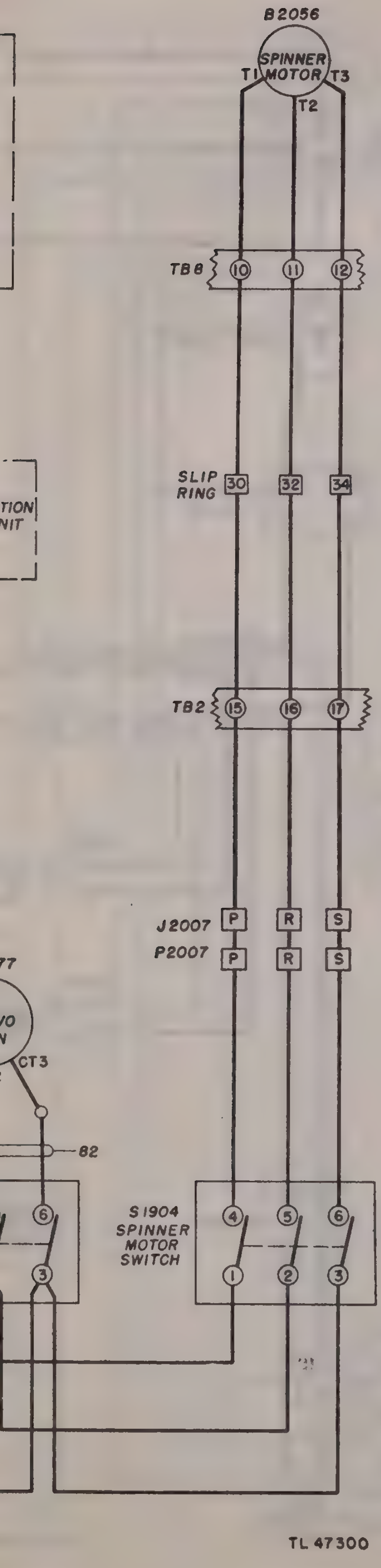

Figure 261. A-c power distribution, schematic diagram.

PART TWO
TROUBLE SHOOTING AND REPAIR
CHAPTER 10
GENERAL INFORMATION

208. INTRODUCTION.

No matter how well equipment is designed and manufactured, faults are bound to occur in service. When such faults do occur, the repairman must locate and correct them as rapidly as possible. This chapter contains general information to aid personnel engaged in the important duty of trouble shooting. (Remember, however, that preventive maintenance will minimize the necessity of trouble shooting.)

a. Trouble-shooting Data. Take advantage of the material supplied in this manual to help in locating faults rapidly. Consult the following trouble-shooting data when necessary:

(*1*) *Block Diagram of the System.*

(*2*) *Complete Schematic Diagrams.* These diagrams include all components and show all the connections (power, input, and output) to other units.

(*3*) *Simplified and Partial Schematics.* These diagrams are particularly useful in trouble shooting because they enable the electrical functioning of the circuits to be followed more clearly than on the complete schematics, thus speeding trouble location.

(*4*) *Voltage and Resistance Data at All Socket Connections.*

(*5*) *Voltage, Resistance, and Waveform Data at Test Jacks.* Blocking capacitors are omitted from most leads to the test jacks to enable measurement of the d-c voltage at the plate or other points to which the test jacks connect. For this reason, be careful not to touch the measuring instruments which carry high voltage when connected to the test jacks.

(*6*) *Illustrations of Components.* Front, top, and bottom views aid in locating and identifying parts.

(*7*) *Pin Connections.* Pin connections on sockets, plugs, and receptacles are numbered or lettered on the various diagrams.

(*a*) Seen from the bottom, pin connections are numbered in a clockwise direction around the sockets. On octal sockets the first pin clockwise from the keyway is pin No. 1. Pin numbers appear on both the schematic diagrams and the voltage-resistance charts so that any tube element can be readily located.

(*b*) Plugs and receptacles are numbered on the side to which the associated connector is attached. To avoid confusion, some individual pins are identified by letters which appear directly on the connector.

b. Trouble-shooting Steps.

(*1*) In servicing a defective radar set the first step is to trace the fault to the system responsible for the faulty operation of the set. Use of the starting procedure aids in tracing the fault to the defective system.

(*2*) The second step is to trace the fault to the component responsible for the faulty system operation. Use of the equipment performance log and the starting procedure aids in tracing the fault to the defective component.

(*3*) The third step is to trace the fault to the abnormal circuit in the defective component. This is done by observing the indications on the scope screens, indicating lights, and meters as the controls and switches are adjusted according to the procedures outlined in the trouble-shooting charts, and by taking the waveforms at key points.

(*4*) The fourth and final step is to trace the fault to the defective part responsible for the abnormal condition in the circuit or stage. Although the fault sometimes can be located by sight, smell, or hearing, it is usually necessary to check voltages and resistances in order to locate the fault.

c. Use of Equipment Performance Log. The equipment performance log is a record of the normal and abnormal operation of the station.

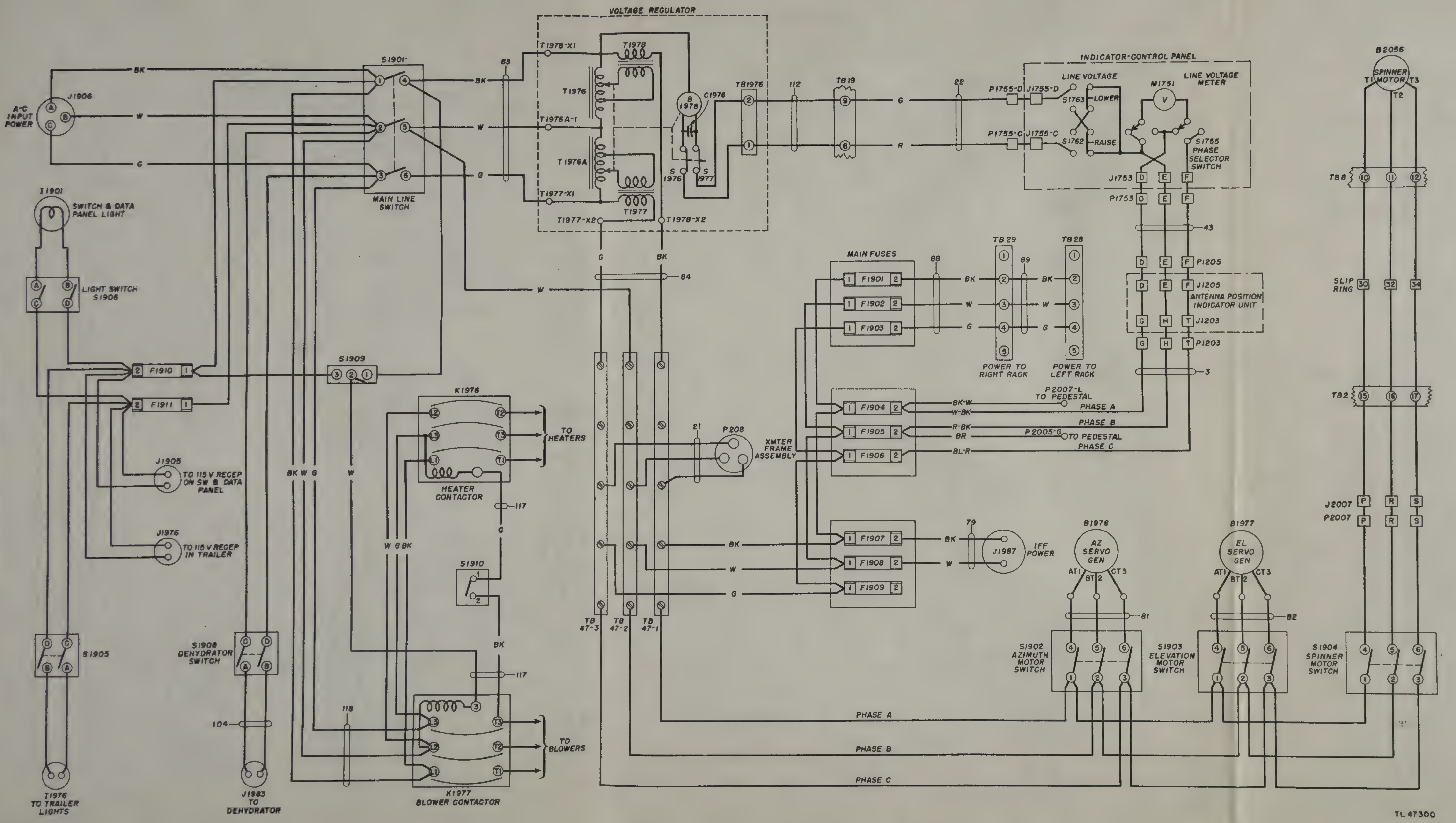

Figure 261. A-c power distribution, schematic diagram.

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PART TWO
TROUBLE SHOOTING AND REPAIR
CHAPTER 10
GENERAL INFORMATION

208. INTRODUCTION.

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a. Trouble-shooting Data. Take advantage of the material supplied in this manual to help in locating faults rapidly. Consult the following trouble-shooting data when necessary:

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(*4*) *Voltage and Resistance Data at All Socket Connections.*

(*5*) *Voltage, Resistance, and Waveform Data at Test Jacks.* Blocking capacitors are omitted from most leads to the test jacks to enable measurement of the d-c voltage at the plate or other points to which the test jacks connect. For this reason, be careful not to touch the measuring instruments which carry high voltage when connected to the test jacks.

(*6*) *Illustrations of Components.* Front, top, and bottom views aid in locating and identifying parts.

(*7*) *Pin Connections.* Pin connections on sockets, plugs, and receptacles are numbered or lettered on the various diagrams.

(*a*) Seen from the bottom, pin connections are numbered in a clockwise direction around the sockets. On octal sockets the first pin clockwise from the keyway is pin No. 1. Pin numbers appear on both the schematic diagrams and the voltage-resistance charts so that any tube element can be readily located.

(*b*) Plugs and receptacles are numbered on the side to which the associated connector is attached. To avoid confusion, some individual pins are identified by letters which appear directly on the connector.

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(*4*) The fourth and final step is to trace the fault to the defective part responsible for the abnormal condition in the circuit or stage. Although the fault sometimes can be located by sight, smell, or hearing, it is usually necessary to check voltages and resistances in order to locate the fault.

c. Use of Equipment Performance Log. The equipment performance log is a record of the normal and abnormal operation of the station.

In the event of station failure or abnormal operation, references to the equipment performance log will usually aid in locating the defect. When a station failure occurs, refer to the log sheet and note the operation of the station for the previous 24 hours. The failure may be the result of a previous abnormal condition not serious enough in itself to have caused the station to go off the air at the time it occurred, but the abnormal condition will have been entered in the station log. Check the log entry to obtain direct information leading to the cause of the failure.

d. Use of Starting Procedure. The starting procedure is the systematic method used to put the station on the air. This procedure is used in locating the fault when the cause of the station failure is not known. In most cases, it will trace the defect to a particular component. The steps of the starting procedure are performed in sequence until an abnormal indication is obtained. As each step is performed, the visible and audible results of the step are noted. The use of the starting procedure is described in detail in chapter 12 of this manual.

e. Use of Trouble-shooting Chart. Chapters 13 to 19 describe the method of localizing faults within the individual components. These sections contain trouble-shooting charts which list abnormal symptoms and their causes. The charts also give the procedure for finding out which of the probable locations of the fault is the exact one.

f. Use of Reference Waveforms. In cases where a fault cannot be isolated to a particular circuit by the steps indicated in the trouble-shooting chart, reference waveforms are given. These waveforms are taken at points made accessible by jacks at the front panel, or by removal of a tube.

g. Use of Voltage and Resistance Charts. Once a fault is traced to a circuit by the steps above, the voltage and resistance charts serve as a guide to isolate the fault before measuring each individual part. Color-code charts and tables are also furnished as aids in determining the electrical rating of a part.

h. Use of Test Cables. A set of test or extension cables is provided with the SCR-784 in order that the various components may be removed from the rack and operated while trouble shooting. These cables are shown in figure 263. The cables are equipped, in practically all cases with a male plug on one end and a female plug on the other. When removing a unit from the rack, it is thus possible to remove the regular interconnection cable from back of the chassis and insert the test cable between it and the proper connector on the chassis. The assortment of cables provided is sufficient to remove any of the chassis and operate it with its more essential circuits connected. It is also possible, in a few cases, to remove more than one chassis at a time, and connect them for operation. Certain special cables are also provided in the set of test cables, which permit using the 32,000- and 2,000-yard range scopes for test purposes.

209. CHECKING WAVEFORMS.

a. Signal Tracing. Basically, signal tracing means following the progress of a signal through a circuit. By signal is meant a video signal, a sweep voltage, a wide-gate voltage, or any other waveform which appears in the various parts of the equipment. A departure from the normal waveform indicates a fault located between the point where the waveform is last normal and the point where it is observed to be abnormal. For example, if a waveform is observed to be normal at the grid of a stage and abnormal at the plate of the same stage, this probably indicates that the trouble lies in that stage.

(*1*) When the waveform of a multivibrator, a blocking oscillator tube, or a similar circuit is found to be abnormal, replace the tube before making any further tests. If replacing the tube does not indicate the correct waveform, place the original tube back in the socket.

(*2*) When a component does not give the expected waveform, the fault is not necessarily in the component. The abnormal waveform may be due to the absence of a synchronizing or triggering pulse from another component. The point at which to start signal-tracing a component is at the input trigger plug.

(*3*) It is sometimes desirable to know definitely whether or not a signal voltage is getting to the grid of the first tube in a channel. To determine this when a test jack is not provided, remove the first tube in the channel involved so as to make the grid connection of the tube available from the top of the chassis. Then insert the test lead of the oscilloscope in the grid connection of the tube socket in order to see the waveform.

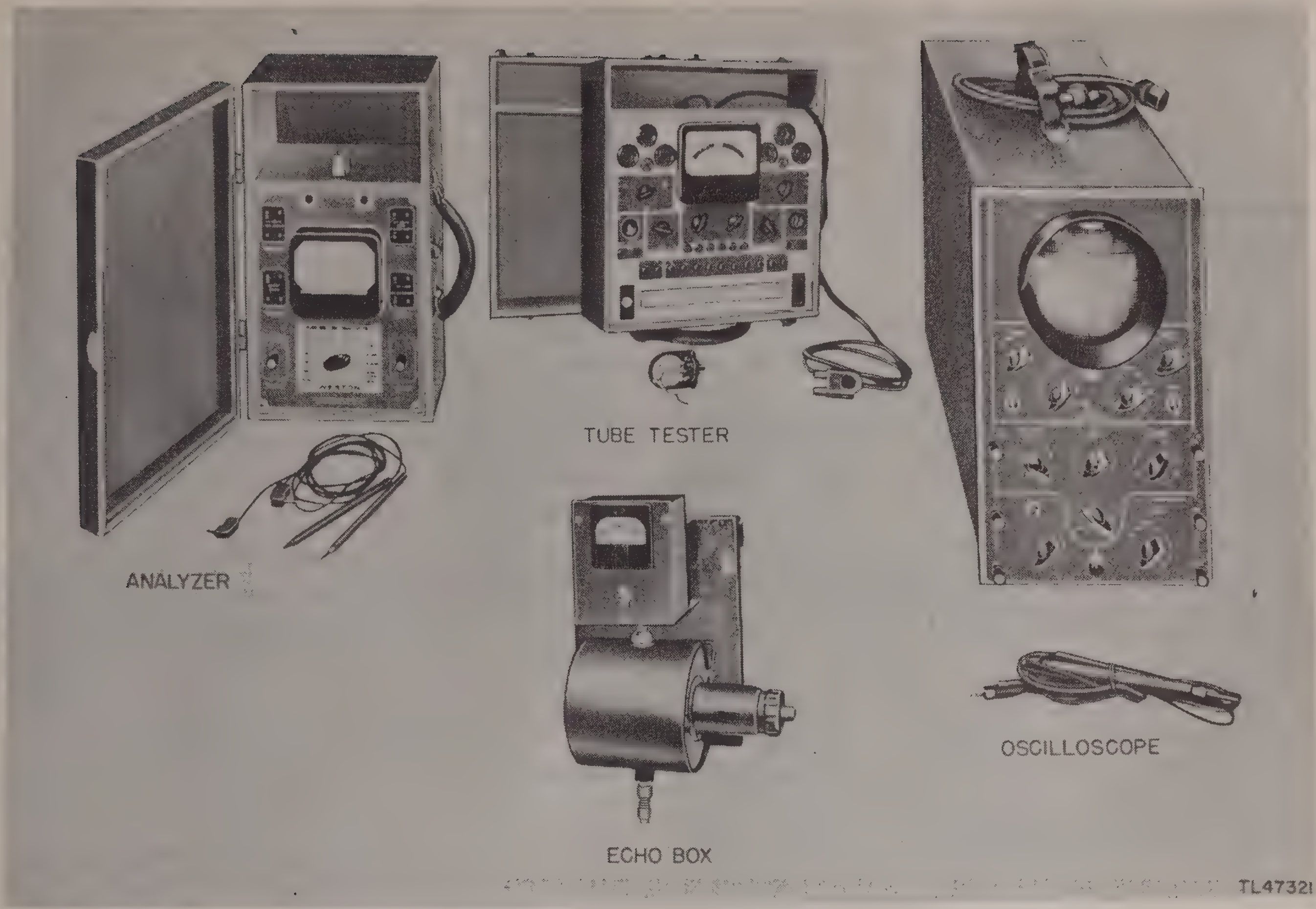


Figure 262. Test equipment.

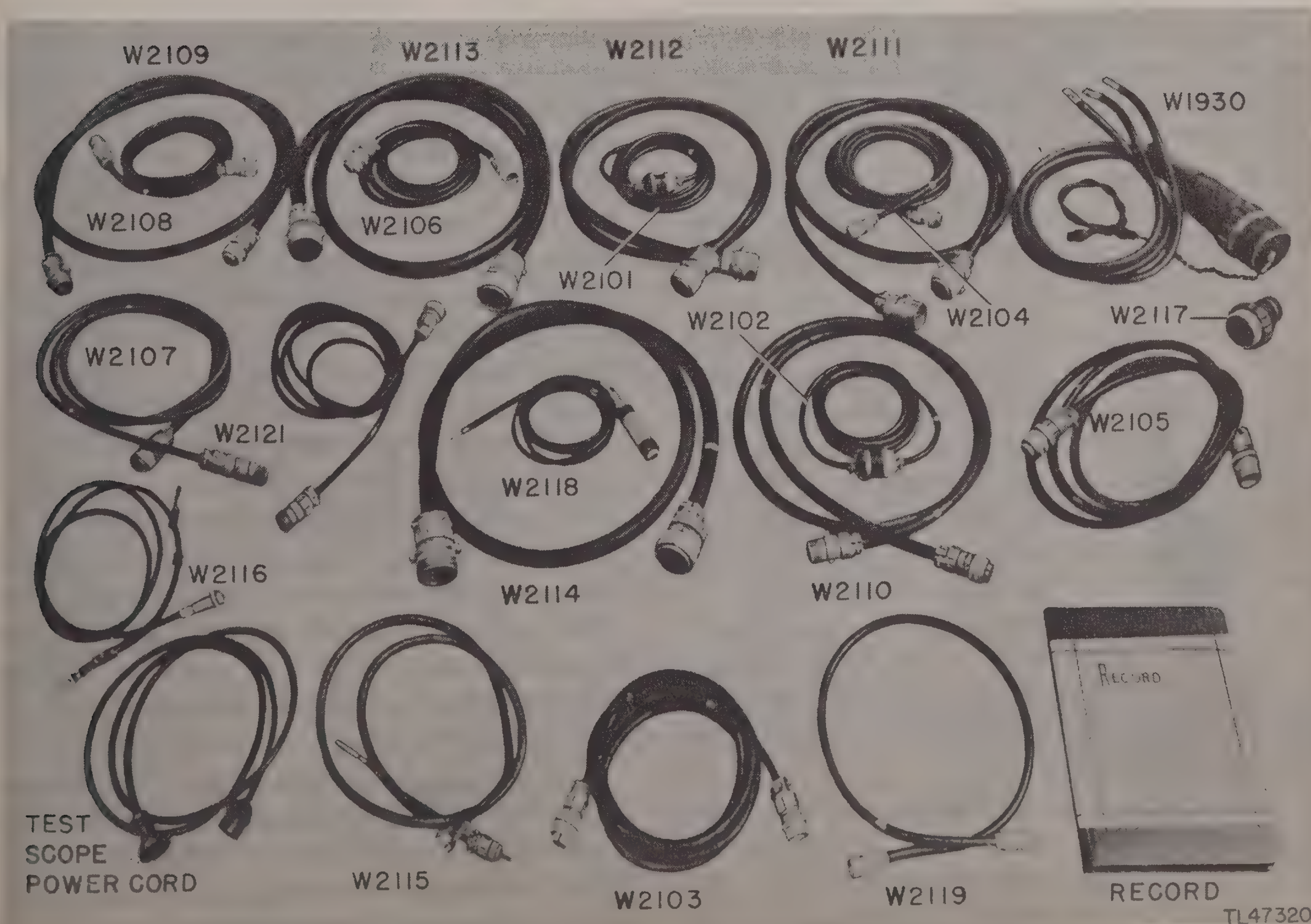


Figure 263. Test cables.

b. Use of Test Oscilloscope. Waveforms are the basis of radar operation. The outstanding advantage of the oscilloscope (fig. 262) is that it can be used to observe and to measure waveforms at the various test jacks and at other points in the equipment. By comparing the observed waveform with the actual reference waveform shown in the data, the fault can be rapidly localized. However, if waveforms are measured at random, without a logical procedure such as that originating with the starting procedure, the result may be a loss of time in finding the fault. The measurement of waveforms with the test oscilloscope involves several essential points:

(*1*) *Initial Adjustments.* The oscilloscope must be set up according to the instructions in the technical manual accompanying the equipment.

(*2*) *Sweep Frequency.* Adjust the frequency of the sweep until it is lower than the repetition frequency of the waveform being observed. For ordinary measurements, adjust the sweep frequency so that 2 or 3 cycles of the waveform being observed appear on the scope. If more detail is desired, increase the sweep amplitude to spread the waveform.

(*3*) *Synchronization.* Avoid excessive synchronizing voltage. If the SYNC control is advanced too far, the sweep will become nonlinear with the result that the waveform will be distorted. Be sure that the fine-frequency control of the oscilloscope is properly set so as to obtain a nearly stationary image. Then advance the SYNC control only far enough to make the trace stationary.

(*4*) *Sixty-cycle Pick-up.* If some fault is present, it may be impossible to obtain a stationary pattern even though the oscilloscope frequency control is properly adjusted. This effect is usually due to the presence of 60-cycle modulation or 60-cycle pick-up combined with the observed waveform. To check, turn the oscilloscope sweep frequency to 30 cycles. If the effect is due to line pick-up, a stationary pattern will be observed. The inside of this pattern will, of course, be more or less filled because of the much higher frequency of the waveform being observed.

(*5*) *Reactions of Oscilloscope on Waveform.* Remember that the oscilloscope, because of its shunt capacitance and resistance across the circuit, modifies the actual operating waveforms present in the circuit. This does ~~not~~ affect the usefulness of waveform measurements. The reference waveforms shown in this manual were taken with a Dumont model 208 oscilloscope under the conditions that are present when the repairman takes the waveforms.

(*6*) *Test Leads.* Avoid the use of a shielded test lead or twisted leads when taking waveforms. Each of these shunts a capacitance across the circuit under test, causing the waveform to be distorted and therefore different from that shown in the data. The waveforms shown in the test data were taken by using an unshielded lead. The ground lead should be connected at all times.

(*a*) Keep the oscilloscope test leads away from other circuits to avoid introducing feedback. The test leads should be brought from the test points in a way which introduces the minimum amount of coupling to other stages.

(*b*) The leads to the oscilloscope must be kept short when measuring grid voltages from circuits where the grid capacitors are small. The smallest reaction on the waveform is introduced when measuring the voltage across the output (cathode) of a cathode follower or of any low-impedance circuit.

(*c*) In measuring waveforms in high-impedance circuits, do not handle the *hot* test lead. If this precaution is not observed, the waveform will be distorted as a result of loading the circuit and picking up 60-cycle voltage.

(*d*) If a signal voltage is picked up on the test leads, the oscilloscope indication may be misleading. For example, a signal may appear on the oscilloscope even when a plate-to-grid coupling capacitor is open. This effect occurs most often in circuits carrying narrow-pulse waveforms. It can be recognized by the fact that the waveform is reduced in amplitude below normal and is distorted because the high-frequency components are overemphasized.

(*7*) *R-f and I-f Circuits.* Do not attempt to measure voltages or waveforms in any of the r-f or i-f circuits with oscilloscopes. These frequencies are beyond the range of ordinary test oscilloscopes, and no indications useful in trouble shooting can be obtained.

(*8*) *Reversing the Line Plug.* In some instances, a more stable pattern may be obtained by reversing the a-c line plug of the oscilloscope. This may reduce the amount of 60-cycle pick-up if it happens to be troublesome.

(*9*) *Relative Amplitude.* In following the path of the signal through a component, the amplitude of the waveform will usually increase as the checking point is advanced from the input stage toward the output stage. However, this is not always true. For example, when going from the grid to the cathode of the cathode-follower stage, there is a loss in signal amplitude of about 10 percent. This is a normal condition. Another example is in connection with wave-shaping circuits where a decrease in the width of a signal is sometimes accompanied by a decrease in amplitude (as in differentiating circuits).

(*10*) *Calibration.* If it is necessary to measure the actual voltage of the waveform, the oscilloscope must be calibrated. Calibrate the oscilloscope by finding how many volts correspond to a 1-inch deflection on the screen. This is the sensitivity of the scope.

(*11*) *High-voltage Measurements.* When voltages above a few hundred volts are measured, connect the test lead with the power turned off.

CAUTION: Some test jacks do not have blocking capacitors. The capacitors are left out so that d-c voltages can be measured at the test jacks.

c. Comparison of Waveforms. If there is no fault in the circuit or equipment, an actual waveform taken at a point in the equipment should closely resemble the reference waveform. In some cases, however, differences in shape may occur for the following reasons:

(*1*) The test leads to the oscilloscope may not be placed in the same manner.

(*2*) A different oscilloscope may be used having values of input resistance and capacitance which differ from those of the oscilloscope used in taking the reference waveforms.

(*3*) The various controls in the equipment may not be in the same positions as when the reference waveforms were taken. Note the conditions specified for the reference waveform.

(*4*) The same number of cycles may not be present.

(*5*) The vertical or horizontal amplitudes of the reference and the test patterns may not be proportional. This will produce apparent differences between the shapes of the two waveforms when there is actually no real difference.

(*6*) Whether or not a waveform is regarded as abnormal will depend upon the symptom accompanying the fault which is being traced. The discrepancy will be considered significant if the fault can be caused by a minor difference in waveform at the point under test. Otherwise time should not be spent in hunting down the cause of relatively minor differences between the shapes of the reference waveforms and the test waveforms.

210. TUBES.

a. Tube Failures. Tube failures are responsible for a large percentage of the faults which occur in radar sets. There are, however, too many tubes in a radar set for a trouble shooter to attempt to find a fault by indiscriminate tube changing. Do not resort to tube changing until the fault has been traced to a particular stage.

(*1*) When putting a new tube into a circuit, note the positions of all controls before making any changes. If retuning the controls with the new tube in the circuit does not correct the abnormal condition, return the controls to their original positions and put the old tube back into the circuit, unless a tube test shows the tube to be definitely bad.

CAUTION: In many radar circuits the interelectrode capacitance of a tube is a part of a tuned circuit. When tubes are switched, the tuning of the circuit is upset. If too many tube substitutions are made, the set may become seriously misaligned.

(*2*) When replacing a tube in a circuit, decide at once whether or not to keep the old tube. Do not change the tubes indiscriminately or the spares box will become full of tubes whose exact age and condition is uncertain.

b. Tube Checking. Tube checkers are used to check the emission of electrons from the cathode, mutual conductance, and to test for shorted elements. Tube checkers will not test the performance of high-voltage tubes or rectifiers or of some special tubes in the modulator and rectifier. Tube checkers are useful, however, for checking receiving-type tubes used in the various components.

(*1*) Results obtained from a tube checker are not always conclusive because the conditions are not the same as those under which the tube operates in the set. For this reason, the final test of a tube must be its replacement with a tube which is known to be good. In many cases it is quicker and more reliable to replace a

suspected tube with a good one than to check it with the tube checker.

(*2*) An operating chart and a technical manual, TM 11-1209, are provided with the Precision 920 tube checker (fig. 262). The chart indicates the setting of the tube checker for each tube type. The number of controls, their arrangement, and their settings are fully discussed in TM 11-1209.

211. VOLTAGE MEASUREMENTS.

a. General. Voltage measurements are an almost indispensable aid to the repairman because most troubles either result from abnormal voltages or produce abnormal voltages. Voltage measurements are made easily because they are always made between two points in a circuit and the circuit need not be interrupted. An Analyzer I-167A (fig. 262) with TM 11-1204 is included with the SCR-784.

(*1*) Complete information on normal operating voltages is given in the trouble-shooting part of this manual. Unless otherwise specified, these voltages are measured between the indicated points and ground.

(*2*) Always begin by setting the voltmeter on the highest range so that the voltmeter will not be overloaded. Then, if it is necessary to obtain increased accuracy, set the voltmeter to a lower range.

(*3*) In checking cathode voltage, remember that a reading can be obtained when the cathode resistor is actually open. The resistance of the meter may act as a cathode resistor. Thus, the cathode voltage may be approximately normal only as long as the voltmeter is connected between cathode and ground. Before the cathode voltage is measured, a resistance check should be made with the circuit cold to determine if the cathode resistor is normal.

b. Precautions Against High Voltage. Certain precautions must be followed when measuring voltages above a few hundred volts. High voltages are dangerous and can be fatal. When it is necessary to measure high voltages, observe the following rules:

(*1*) Connect the ground lead to the voltmeter.

(*2*) Place one hand in your pocket.

(*3*) If the voltage is less than 300 volts, connect the test lead to the hot terminal (which may be either positive or negative with respect to ground).

(*4*) If the voltage is greater than 300 volts, shut off the power, connect the hot test lead, step away from the voltmeter, turn on the power, and note the reading on the voltmeter. Do not touch any part of the voltmeter, particularly when it is necessary to measure the voltage between two points both of which are above ground.

c. Voltmeter Loading. It is essential that the voltmeter resistance be at least 10 times as large as the resistance of the circuit across which the voltage is measured. If the voltmeter resistance is comparable to the circuit resistance, the voltmeter will indicate a lower voltage than the actual voltage present when the voltmeter is removed from the circuit.

(*1*) The resistance of the voltmeter on any range can always be calculated by the following simple rule: resistance of voltmeter equals the ohms-per-volt multiplied by the full-scale range in volts. For example, the resistance of a 1,000-ohm-per-volt voltmeter on the 300-volt range is 1,000 ohms-per-volt x 300 volts = 300,000 ohms.

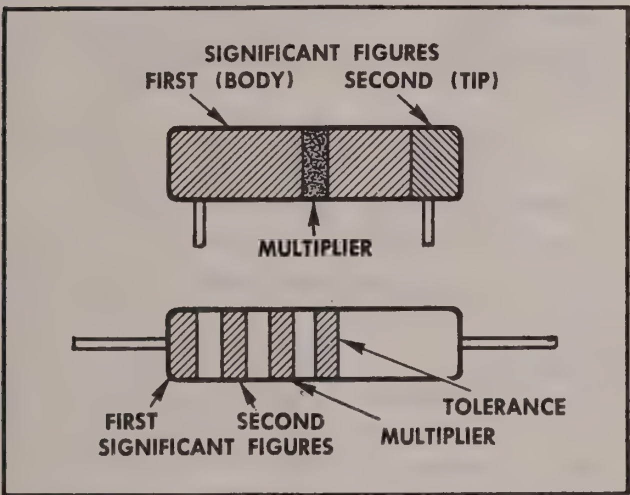
(*2*) To minimize voltmeter loading in high-resistance circuits, use the highest voltmeter range. Although only a small deflection will be obtained (possibly only 5 divisions on a 100-division scale), the accuracy of the voltage measurement will be increased. The decreased loading of the voltmeter will more than compensate for the inaccuracy which results from reading only a small deflection on the scale of the voltmeter.

(*3*) When a voltmeter is loading a circuit, the effect can always be noted by comparing the voltage reading on two successive ranges. If the voltage readings on the two ranges do not agree, voltmeter loading is excessive. The reading (not the deflection) on the highest range will be greater than on the lowest range. If the voltmeter is loading the circuit heavily, the deflection of the pointer will remain nearly the same on the scale when the voltmeter is shifted from one range to another.

(*4*) The voltage and resistance drawings used in this manual are based on readings taken with an actual meter. The ohms-per-volt sensitivity of the meter which was used is printed on the drawings. The trouble shooter should use a meter having the same ohms-per-volt sensitivity. Because the meter used in testing for the voltage will produce the same amount of loading as the meter used in measuring the voltage, it is unnecessary to consider the effect of loading.

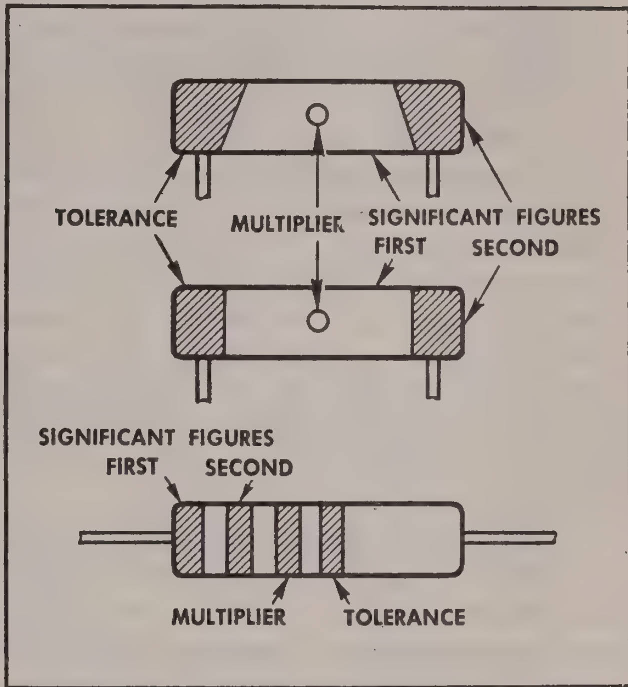
RESISTOR COLOR CODES

RMA COLOR CODE FOR FIXED COMPOSITION RESISTORS



Insulated fixed composition resistors with axial leads are designated by a natural tan background color. Non-insulated fixed composition resistors with axial leads are designated by a black background color.

AWS COLOR CODE FOR FIXED COMPOSITION RESISTORS



The exterior body color of insulated resistors may be any color except black. The usual color is natural tan. The exterior body color of uninsulated resistors with axial leads may be either black or white. The exterior body color of uninsulated resistors with radial leads may be black or it may be the color of the first significant figure of the resistance value.

COLOR	SIGNIFICANT FIGURE	MULTIPLIER	TOLERANCE (PERCENT)
BLACK	0	1	
BROWN	1	10	
RED	2	100	
ORANGE	3	1000	
YELLOW	4	10,000	
GREEN	5	100,000	
BLUE	6	1,000,000	
VIOLET	7	10,000,000	
GRAY	8	100,000,000	
WHITE	9	1,000,000,000	
GOLD		0.1	5
SILVER		0.01	10
NO COLOR			20

RMA: *Radio Manufacturers Association*
AWS: *American War Standard (American Standards Association)*

TL 13418

Figure 264. Resistor color code.

212. RESISTANCE MEASUREMENTS.

a. General.

(*1*) *Normal Resistance Values.* When a fault develops in a circuit, its effect will very often show up as a change in the resistance values. To assist in the localization of such faults, trouble-shooting data includes the normal resistance values as measured at the tube sockets and at the test jacks. These values are measured between the indicated points and ground, unless otherwise stated. Often it is desirable to measure the resistance from other points in the circuit in order to determine whether the particular points in the circuit are normal. The normal resistance values at any point can be determined by referring to the resistance values shown in the schematic diagram, or by use of the voltage-resistance charts. A resistance color code is shown in figure 264 for checking resistance values against the values shown on the schematic diagram.

(*2*) *Precautions.*

(*a*) Before making any resistance measurements, turn off the power. An ohmmeter circuit in the Analyzer I-167A is essentially a low-range voltmeter and battery. If the ohmmeter is connected to a circuit which already has voltages in it, the needle will be knocked off scale and the voltmeter movement may be burned out.

(*b*) Capacitors must always be discharged before resistance measurements are made. This is very important when checking power supplies that are disconnected from their load. The discharge of the capacitor through the meter will burn out its movement and in some cases may endanger life.

(*3*) *Correct Use of Low and High Ranges.* It is important to know when to use the low-resistance range and when to use the high-resistance range of an ohmmeter. When checking the circuit continuity, the ohmmeter should be set on the lowest range. If a medium or high range is used, the pointer may indicate zero ohms, even if the resistance is as high as 500 ohms. When checking high resistances or measuring the leakage resistance of capacitors or cables, the highest range should be used. If a low range is used, the pointer will indicate infinite ohms, even though the actual resistance is less than a megohm.

(*4*) *Parallel-resistance Connections.* In a parallel circuit the total resistance is less than the smallest resistance in the circuit. This is important to remember when trouble shooting with the aid of a schematic diagram.

(*a*) When a resistance is measured and the value is found to be less than expected, make a careful study of the schematic to be certain that there are no resistances in parallel with the one that has been measured. Before replacing a resistor because its resistance measures too low, disconnect one terminal from the circuit and measure its resistance again to make sure that the low reading does not occur because some part of the circuit is in parallel with the resistor.

(*b*) In some cases it will be impossible to check a resistor because it has a low-voltage transformer winding connected across it. If the resistor must be checked, disconnect one terminal from the circuit before measuring its resistance.

(*5*) *Checking Grid Resistance.* When checking grid resistance, a false reading may be obtained if the tube is still warm and the cathode is emitting electrons. Allow the tube to cool, or reverse the ohmmeter test leads so that the negative ohmmeter test lead is applied to the grid.

(*6*) *Tolerance Values for Resistance Measurements.* Tolerance means the normal difference that is expected between the rated value of the resistor and its actual value. Most resistors that are used in radar circuits have a tolerance of at least 10 percent. For example, the grid resistor of a stage might have a rated value of 1 megohm. If the resistor were measured and found to have a value between 0.9 megohm and 1.1 megohms, it would be considered normal. As a rule, the ordinary resistors used in circuits are not replaced unless their values are off more than 20 percent. Some precision resistors and potentiometers are used.

b. High-resistance Measurements. Many leakages will not show up when measured at low voltages. Most ohmmeters use a maximum test voltage of 15 volts on the highest resistance range. Where it is necessary to measure resistance above a few megohms or the leakage resistance between conductors of a cable, the test should be made using an applied voltage of 100 volts or more. Where it is possible to ground one end of the resistance being checked, one of the low-voltage power supplies in the equipment can be used to provide about 300 volts for making these high-resistance measurements. The manner in which such measurements are made is indicated in figure 265. This method should

be used only when the resistance being measured is very high. Be careful not to handle the meter after the circuit has been completed. The meter used should have an ohms-per-volt sensitivity of 1,000 ohms or more. The resistance of the meter is equal to the ohms-per-volt sensitivity multiplied by the range to which the meter is set. The derivation of the formula $R_x = \frac{300R_m}{V}$ is shown below. R_x is the known resistance, R_m is the meter resistance, and V is the voltmeter reading.

$$\frac{R_x}{R_m} = \frac{300 - V}{V}$$

If R_x is very large, V will be small in comparison to 300. Assuming that $300 - V$ can be replaced by 300, the formula $\frac{R_x}{R_m} = \frac{300}{V}$ is obtained. When solved for R_x this gives $R_x = \frac{300R_m}{V}$. When making the measurement, the meter should first be put on the 300-volt scale to protect it in case R_x is very low. If the voltage used is not 300 volts, the correct value should be inserted in the formula in place of 300.

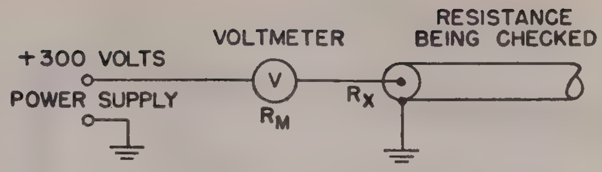
213. CAPACITOR TESTS.

Capacitors which are leaky or shorted can be found by resistance checks of the stage. A capacitor which is suspected of being open can best be checked by shunting a good capacitor across it. In intermediate-frequency (i-f) circuits, keep the leads to the capacitor as short as the original capacitor's leads. In video and low-frequency circuits (less than 1 megacycle) the test capacitor leads may be several inches long. A capacitor color code is shown in figure 266 for checking the capacitor value against the value shown on the circuit diagram.

214. CURRENT MEASUREMENTS.

Current measurements, other than those indicated by the panel meters, are not ordinarily required in trouble shooting in the radar set. Under special circumstances where the voltage and resistance measurements by themselves are not sufficient to localize the trouble, a current measurement can be made by opening the circuit and connecting the ammeter to measure the current. This procedure is not recommended except in very difficult cases.

a. When the meter is inserted in a circuit to measure current it should always be inserted



$R_X = \frac{300}{V} R_M$ (APPROX.)

EXAMPLE

V = 5 VOLTS. THE METER IS USED ON ITS 300 VOLT RANGE AND HAS A RESISTANCE OF 1,000 OHMS-PER-VOLT.

R_M = 300 X 1,000 = 300,000 OHMS.

$R_X = \frac{300}{5}$ X 300,000 = 18 MEGOHMS.

TL 35530

Figure 265. Measurement of high resistance.

away from the r-f end of the resistance. For example, when measuring plate current, do not insert the meter next to the plate of a tube, but insert it next to the end of the resistor which connects to the power. This precaution is necessary to keep the meter from upsetting the r-f voltages.

> **CAUTION:** A meter has least protection against damage when it is used to measure current. Always set the current range to the highest value. Then if necessary, decrease the range to give a more accurate reading. Avoid working close to full-scale reading because this increases the danger of overload.

b. In most cases, the current to be measured flows through a resistance which is either known or can be measured with an ohmmeter. The current flowing in the circuit can be determined by dividing the voltage drop across the resistor by its resistance value. The drop across the cathode resistor is a convenient method of determining the cathode current. For example, if the voltage drop across a 500-ohm resistor is 10 volts, then the current flowing through the resistor is $10 \div 500$ or 0.02 amperes (20 ma).

215. REPLACING PARTS.

Careless replacement of parts often makes new faults inevitable. Note the following points:

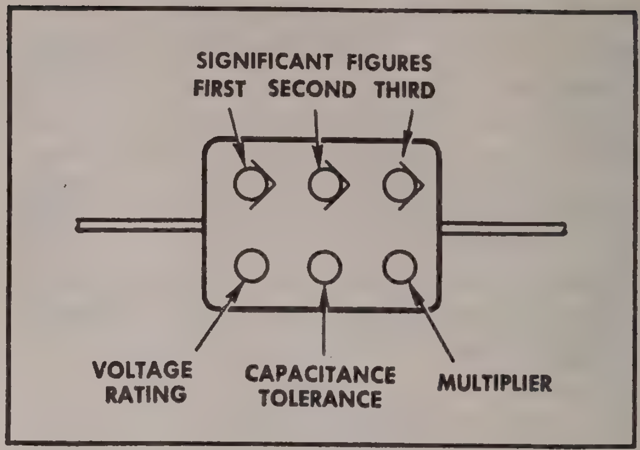
a. Before a part is unsoldered, note the position of the leads. If the parts, such as a transformer, has a number of connections to it, tag each of the leads.

b. Be careful not to damage other leads by pulling or pushing them out of the way.

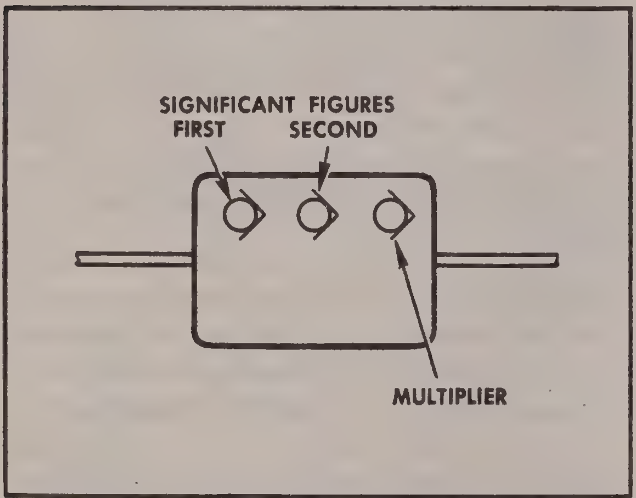
927739 O—51——18

CAPACITOR COLOR CODES

RMA 6-DOT COLOR CODE FOR MICA-DIELECTRIC CAPACITORS

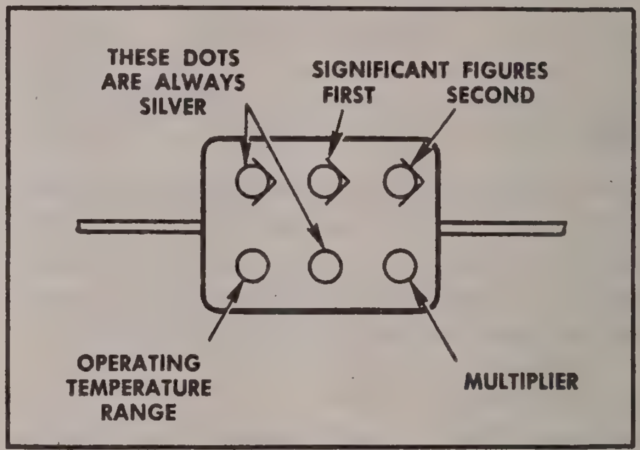


RMA 3-DOT COLOR CODE FOR MICA-DIELECTRIC CAPACITORS



Capacitors marked with this code have a voltage rating of 500 volts.

AWS 6-DOT COLOR CODE FOR PAPER-DIELECTRIC CAPACITORS



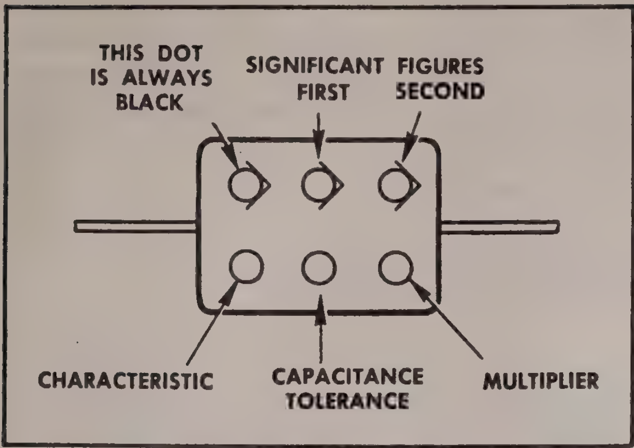
The silver dots serve to identify this marking. The sixth dot shows whether the capacitor has a maximum operating temperature of 167°F (black) or 185°F (brown).

COLOR	SIGNIFICANT FIGURE	MULTIPLIER		VOLTAGE RATING (VOLTS)	CHARACTERISTIC (AWS MICA-DIELECTRIC)
		RMA MICA- AND CERAMIC-DIELECTRIC AWS MICA- AND PAPER-DIELECTRIC	AWS CERAMIC-DIELECTRIC		
BLACK	0	1	1		A
BROWN	1	10	10	100	B
RED	2	100	100	200	C
ORANGE	3	1000	1000	300	D
YELLOW	4	10,000		400	E
GREEN	5	100,000		500	F
BLUE	6	1,000,000		600	G
VIOLET	7	10,000,000		700	
GRAY	8	100,000,000	0.01	800	
WHITE	9	1,000,000,000	0.1	900	
GOLD		0.1		1000	
SILVER		0.01		2000	
NO COLOR				500	

TL 13417-1

Figure 266. Capacitor color codes.

AWS 6-DOT COLOR CODE FOR MICA-DIELECTRIC CAPACITORS



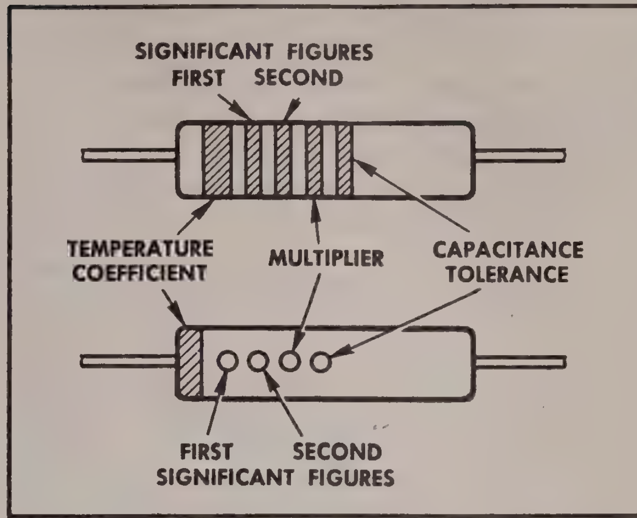
The black dot serves to identify the AWS marking. Capacitors marked with this code are rated at 500 volts, except the following. AWS type CM35 capacitors with capacitances of 6,800, 7,500, and 8,200 micromicrofarads, and AWS type CM40 capacitors with capacitances of 9,100 and 10,000 micromicrofarads are rated at 300 volts.

RMA: *Radio Manufacturers Association*

AWS: *American War Standard (American Standards Association)*

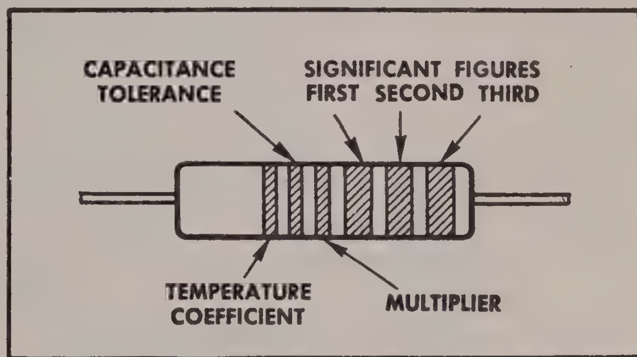
NOTE: These color codes give all capacitances in *micromicrofarads.*

AWS COLOR CODE FOR TUBULAR CERAMIC-DIELECTRIC CAPACITORS



Capacitors marked with this code have a voltage rating of 500 volts.

RMA COLOR CODE FOR TUBULAR CERAMIC-DIELECTRIC CAPACITORS



Capacitors marked with this code have a voltage rating of 500 volts.

CAPACITANCE TOLERANCE				TEMPERATURE COEFFICIENT OF CAPACITANCE $\times 10^{-6}$ MMF/MMF/°C
RMA & AWS MICA- AND PAPER-DIELECTRIC (PERCENT)	RMA CERAMIC-DIELECTRIC (PERCENT)	AWS CERAMIC-DIELECTRIC GREATER THAN 10 MMF (PERCENT)	AWS CERAMIC-DIELECTRIC LESS THAN 10 MMF (MMF)	
20	20	20	2.0	0
1	1	1		− 30
2	2	2		− 80
3	3	2.5	0.25	−150
4	4			−220
5	5	5	0.5	−330
6	6			−470
7	7			−750
8	2.5			+ 30
9	10	10	1.0	Not specified
5				
10				
20				

TL 13417-2

Figure 266. Capacitor color codes.

c. Do not allow drops of solder to fall into the set since they may cause short circuits.

d. A carelessly soldered connection may create a new fault. It is very important to make well-soldered joints, since a poorly soldered joint is one of the most difficult faults to find.

e When a part is replaced in an r-f or i-f circuit, it must be placed exactly as the original one was. A part which has the same electrical value but different physical size may cause trouble in high-frequency circuits. Give particular attention to proper grounding when replacing a part. Use the same ground point as in the original wiring. Failure to observe these precautions may result in decreased gain or possibly in oscillation of the circuit.

CHAPTER 11
THEORY AND USE OF ECHO BOX

SECTION I
DESCRIPTION AND FUNCTION

216. PURPOSE.

a. The echo box and its associated test apparatus is designed to perform the following checks and measurements on the operation of Radio Set SCR-784.

(*1*) Indication of proper tune-up.

(*2*) Check of over-all r-f system performance.

(*3*) Indication of transmitter power output.

(*4*) Measurement of transmitter frequency.

(*5*) Analysis of transmitter frequency spectrum.

(*6*) Measurement of local-oscillator frequency.

(*7*) Indications for trouble shooting.

b. The echo box is useful for a day-to-day check on the transmitting system and receiving system performance. Its periodic use will insure the prompt discovery of any reduction in the set's performance. It is important to note that the echo box cannot be used to make comparative measurements between various sets.

c. Rapid trouble shooting is possible with the echo box. Figure 267 lists some causes of improper operation of the radar set and the corresponding indications given by the echo box.

217. GENERAL DESCRIPTION.

a. The echo box is a cylindrical cavity approximately 6 inches in diameter and 5½ inches long. Inside the cylinder is a movable piston or plunger, which moves axially to vary the length of the cavity. When the plunger knob is turned clockwise, the plunger moves into the cavity and decreases the cavity length. A scale with a marker, and the position of the tuning knob are used with a calibration chart to determine the resonant frequency of the cavity.

b. Radio frequency energy is inductively coupled in and out of the cavity by means of coupling loops in the sides and parallel to the ends of the box. The inside of the cavity is silver-plated and highly polished to increase efficiency. A small amount of radio-frequency absorbing material is placed in the small cavity behind the plunger to prevent this cavity from affecting the operation. Figure 268 is an outline drawing showing the main parts of the echo box.

c. The energy absorbed by the echo box is indicated by a microammeter connected to one of the coupling loops. The echo box, microammeter and calibration chart are mounted in the right-front skirt box of the trailer (fig. 269).

218. TEST APPARATUS.

The echo box and echo box indicator assembled as a unit consist of the following components:

a. Echo box.

b. Echo box indicator consisting of the following:

(*1*) One coupling loop and crystal holder.

(*2*) One U. S. Navy type 1N21 crystal or equivalent.

(*3*) One d-c meter, 0-200 microampere, approximately 600-ohm coil resistance.

(*4*) One capacitor, 2-microfarad, rated for 600 volts.

(*5*) One switch and shunt resistor to reduce meter readings by factor of ten.

(*6*) One meter box inclosing end of crystal holder, crystal, meter, capacitor, switch, and shunt resistor listed above.

c. One coupling loop with U. S. Navy type 49128 jack connector.

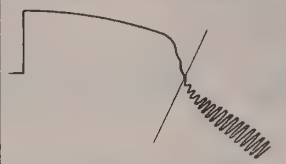
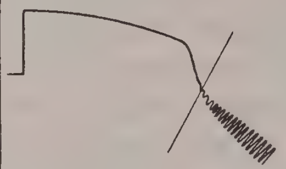
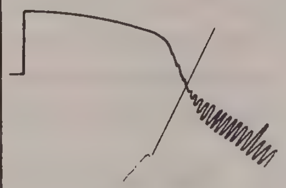
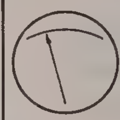
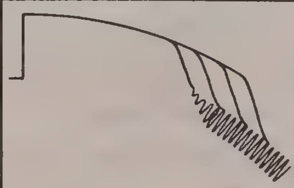
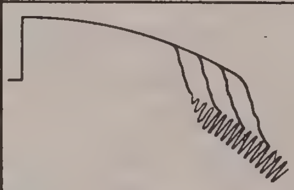
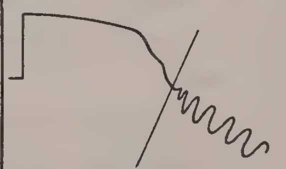
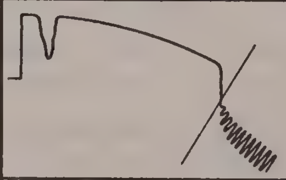
d. One mounting plate with snap fasteners for holding the echo-box unit to the side of the skirt box.

e. One frequency calibration chart.

f. One pick-up dipole.

g. One dipole mounting rod and bracket, and miscellaneous hardware.

h. Necessary interconnecting cables.

EFFECT	APPEARANCE ON 32,000 YARD RANGE SCOPE	APPEARANCE ON ECHO BOX METER	CAUSE AND PROBABLE REMEDY
RINGING TIME SATISFACTORY			SYSTEM PERFORMANCE SATISFACTORY
RINGING TIME VERY LOW, CRYSTAL CURRENT SATISFACTORY			RECEIVER TROUBLE: LOCAL OSCILLATOR; BAD CRYSTAL; EXCESSIVE I-F NOISE FROM 1ST PRE-AMP STAGE AND/OR PICKUP FROM MOTORS; DETUNED T/R BOX; T/R TUNING PLUGS NOT LOCKED TIGHTLY.
RINGING TIME LOW, CRYSTAL CURRENT EQUALLY LOW.			LOW POWER OUTPUT CHECK SPECTRUM
RINGING TIME VERY LOW, CRYSTAL CURRENT LOW.			TROUBLE PROBABLY IN TRANSMITTER AND RECEIVER; AND/OR TROUBLE IN TRANSMISSION LINE: CHECK FOR EXCESSIVELY HOT STUBS ON TRANSMISSION LINE, WATER IN LINE, CORRODED OR POOR CONNECTIONS
RINGING TIME ERRATIC, CRYSTAL CURRENT STEADY.			SPINNER MOTOR ON, OR FAULTY PULSING; DOUBLE MODING TRANSMITTER, OR LOCAL OSCILLATOR TROUBLE. CHECK SPECTRUM INTERMITTENT CONTACTS IN CABLES OR RECEIVER.
RINGING TIME ERRATIC, CRYSTAL CURRENT ERRATIC			FAULTY TRANSMISSION LINE OR POOR CONNECTIONS, CONDITION WORSE WHEN LINE IS RAPPED.
END OF RINGING TIME IS NOT STEEP, SLOPES GRADUALLY; PERHAPS EVEN EXCESSIVE RINGING.			OSCILLATING I.F. AND/OR NARROW BAND RECEIVER. "GRASS" APPEARS COARSE AND SAWTOOTH RATHER THAN FINE AND NEEDLE-LIKE.
DIP IN RINGING TIME AT END OF PULSE.			BAD T/R TUBE
POOR SPECTRUM			TRANSMITTER TROUBLE

TL-34469

Figure 267. Cause and effect chart.

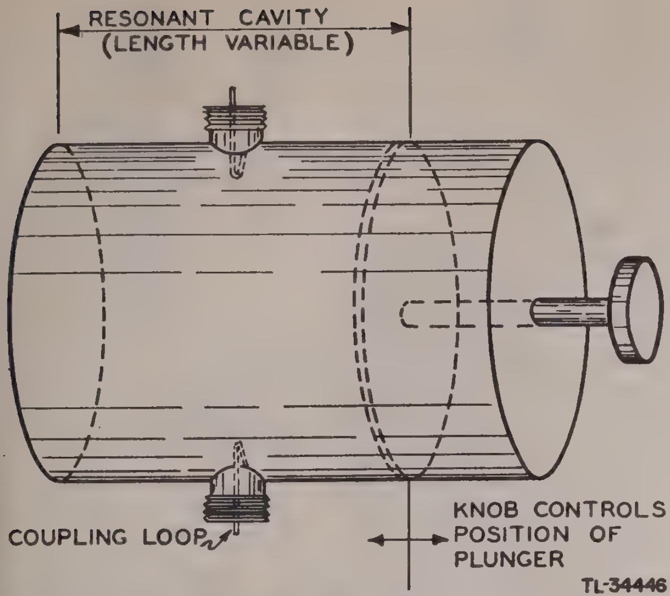


Figure 268. Echo box, outline drawing.

219. THEORY OF OPERATION.

a. Resonant Cavity of Echo Box. Electrically, the echo-box cavity is equivalent to a sharply tuned L-C resonant circuit (fig. 270). However, it is not correct to consider any particular part of the box as either the capacitance or inductance of the equivalent circuit. The frequency to which the box is resonant is dependent upon the physical size of the resonant cavity. The physical size of the cavity is changed by moving the plunger. When the length of the cavity is decreased, the resonant frequency is raised. When the length of the cavity is increased, the resonant frequency is lowered.

b. Echo Box as Small Transmitter. R-f energy from the radar antenna is picked up by the small test dipole and is fed into the echo-box cavity through an r-f cable and a coupling loop (fig. 270). During the radar pulse, the resonant cavity of the echo box accepts r-f energy, and oscillations build up for the duration of the radar pulse. After the radar pulse has stopped, the oscillations in the echo box continue but gradually die out (fig. 271) because some of the energy is dissipated in the resonant cavity, some is coupled out to the crystal rectifier and microammeter, and some is coupled out to the

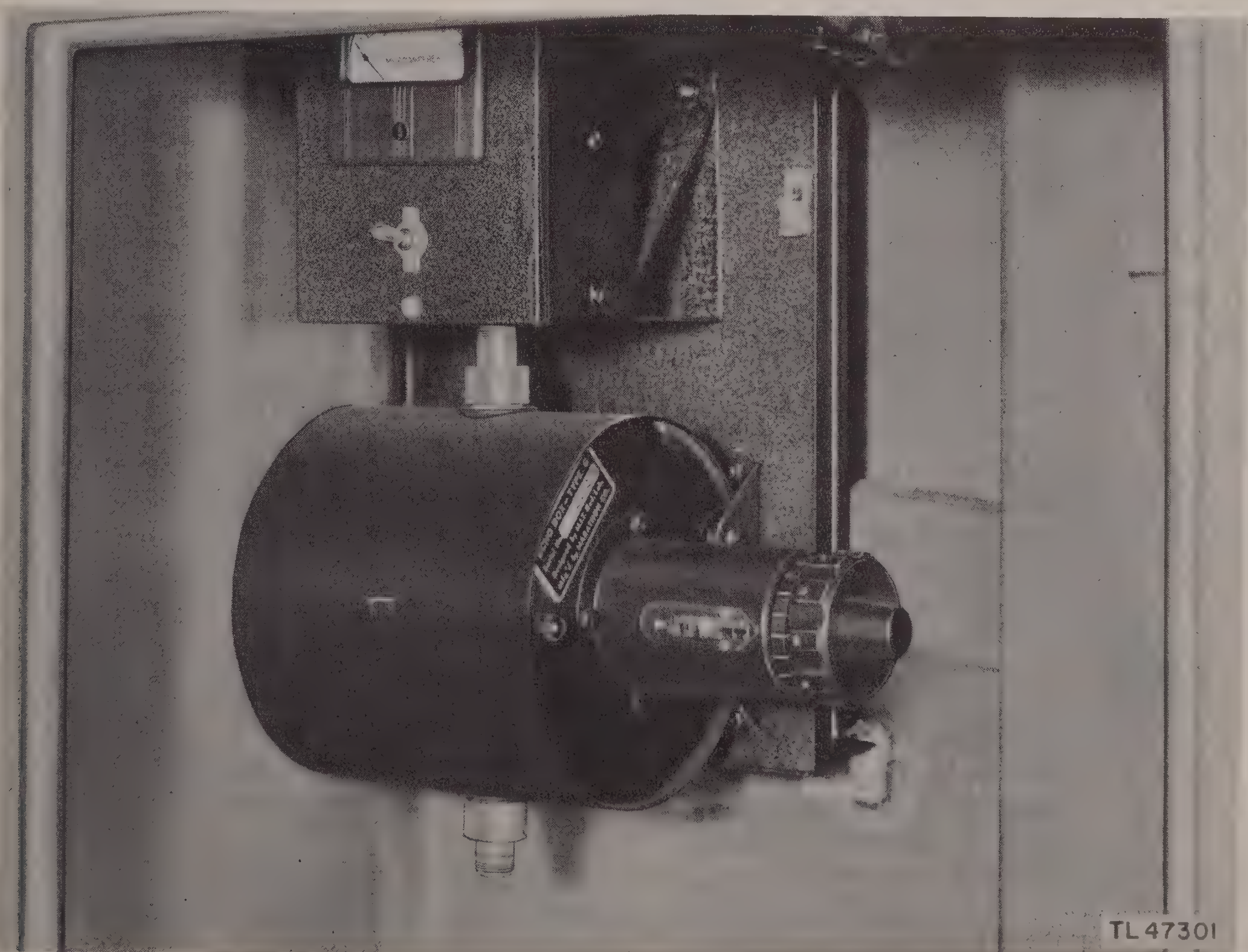


Figure 269. Echo box mounted in skirt box.

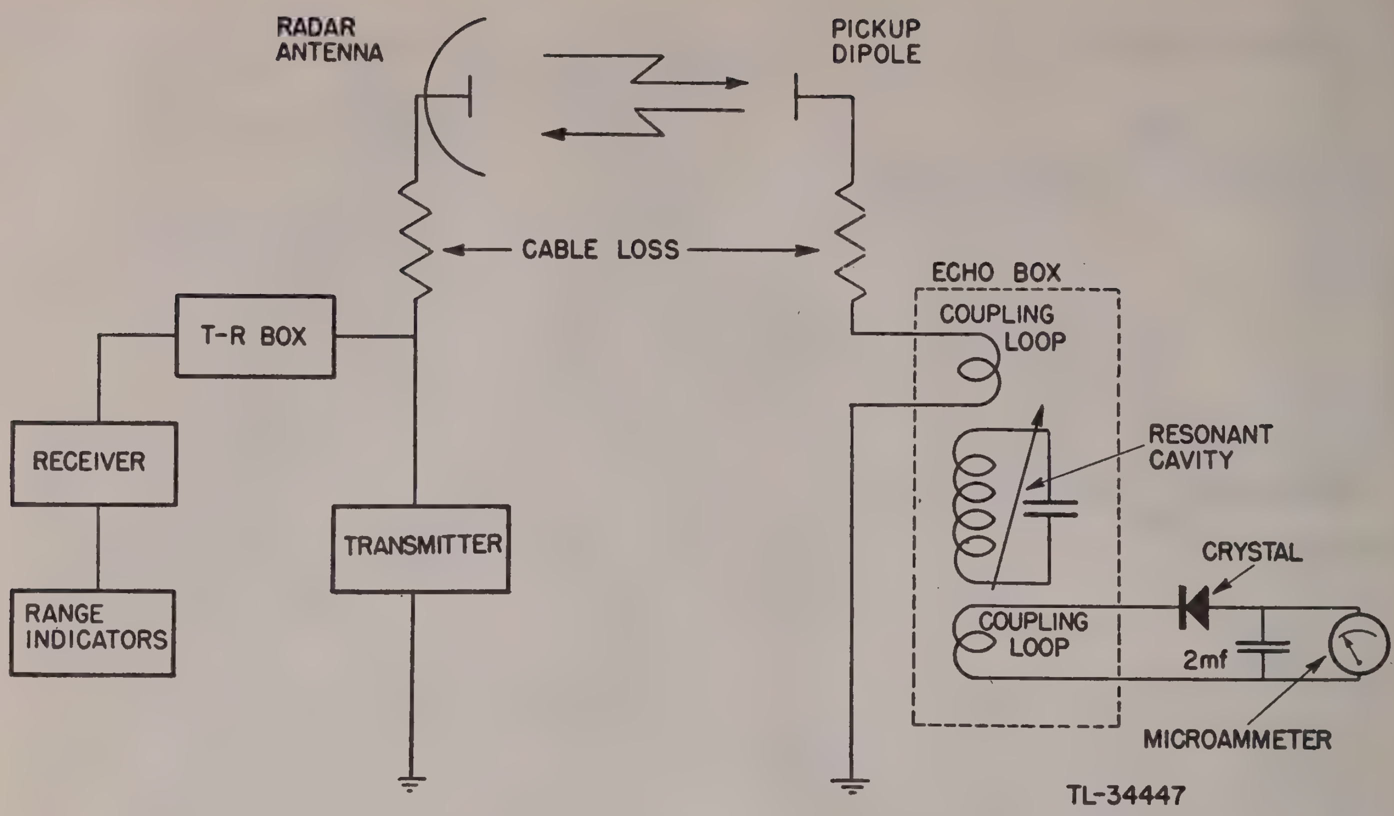


Figure 270. Echo box equivalent circuit.

pick-up dipole. This energy is then radiated from the pick-up dipole and is detected by the radar receiver and appears on the range scopes. The echo box, therefore, acts as a miniature transmitter which begins to transmit immediately after the radar pulse has stopped being transmitted.

c. Ringing Time. Because of the large amount of power received and returned by the echo box, the received signals will, for the most part, appear on the range scopes as a solid block with a flat top at the receiver-saturation amplitude (figs. 272 and 273). The oscillations die out exponentially and this portion of the curve can be seen from the end of the flat top to the noise or grass level. The time from the beginning of the transmitted pulse to the point where the signal from the echo box fades into the noise level is known as the "ringing time" of the box. The ringing time is measured in terms of range in yards on the range scopes. The observed ringing time is dependent upon several factors. Some of the constant factors, such as characteristics of the echo box, pick-up dipole, cabling, and coupling loops in the echo box, are a part of the contruction and test circuit and do not enter into any of the comparative measurements or indications. Other factors, such as power output of the transmitter, pulse duration, frequency spectrum, and receiver condition and tuning, vary with the performance of the radar system. Therefore, if all factors external to the radar system are standardized, the ringing time will depend only upon the performance of the radar system.

d. Output Indication. When the echo box is tuned to resonance, energy may be coupled out of the box and into the crystal rectifier. Refer to figure 270. The crystal current, filtered by a capacitor, is measured by a microammeter. The crystal current, as measured by the microammeter, indicates the amount of energy absorbed by the echo box. Thus, the microammeter indication will serve to indicate the radar power output and condition of the transmitter tuning.

e. Bandwidth of Echo Box. The tuning of the resonant cavity is very sharp since the echo box will accept only energy in a bandwidth of 0.085 megacycle. This characteristic is used in making the frequency-spectrum analysis discussed in paragraph 225.

f. Temperature Corrections. The electrical resistance and shape of the echo box change somewhat with the temperature, thus changing the ringing time. Table IV gives the correction

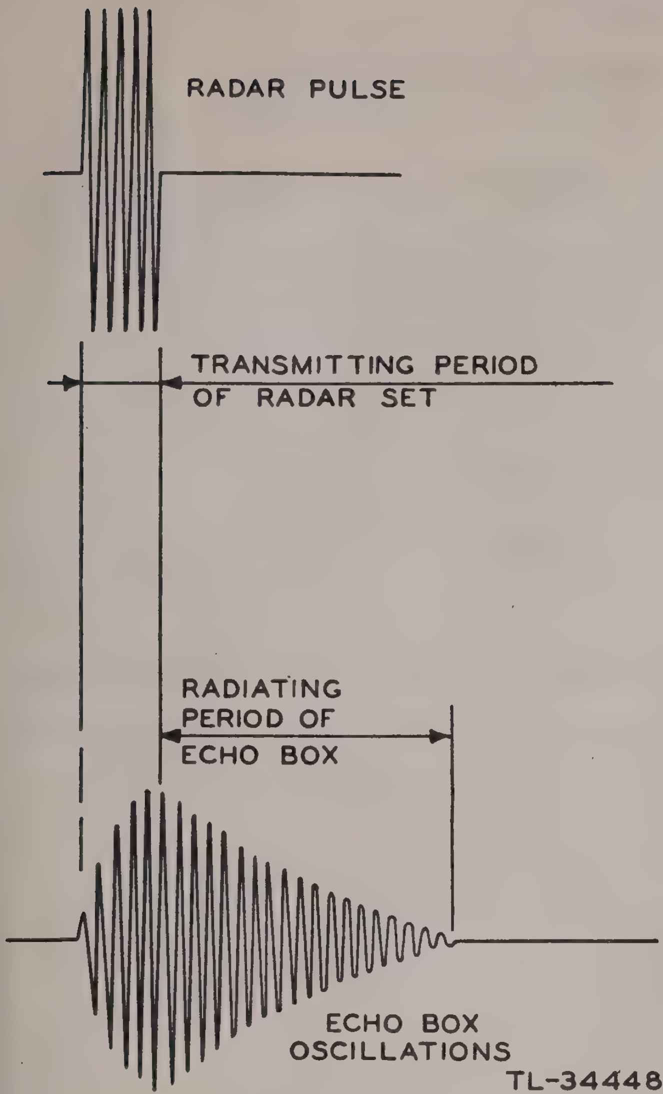


Figure 271. Echo box oscillations.

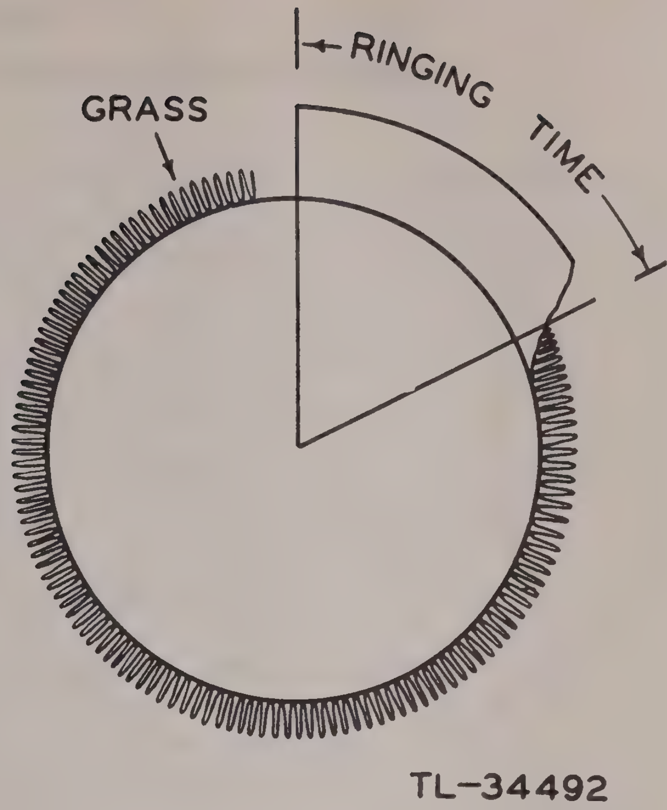


Figure 272. Ringing time on 32,000-yard range scope.

to be added to or subtracted from the observed ringing time for normal operating temperatures. For example, if operating temperature is 40°F, add 70 yards to the observed ringing time. If the temperature is 80°F, subtract 70 yards from the observed ringing time. Interpolations to 5° will give reasonable accuracy. If dark-colored echo boxes are left in bright sunlight a sufficient temperature rise may be caused to lower the ringing time by 100 yards.

g. Advantages of Echo Box Over Ground Signal for Tuning Set. Radio Set SCR-784 may be tuned more accurately by means of the echo box than by near-by ground echoes. The echo box gives a true indication of performance while such received signals usually do not. A ground signal, to be a good tuning indicator, must be very steady, and its type and characteristics must be known. If such a signal shows any

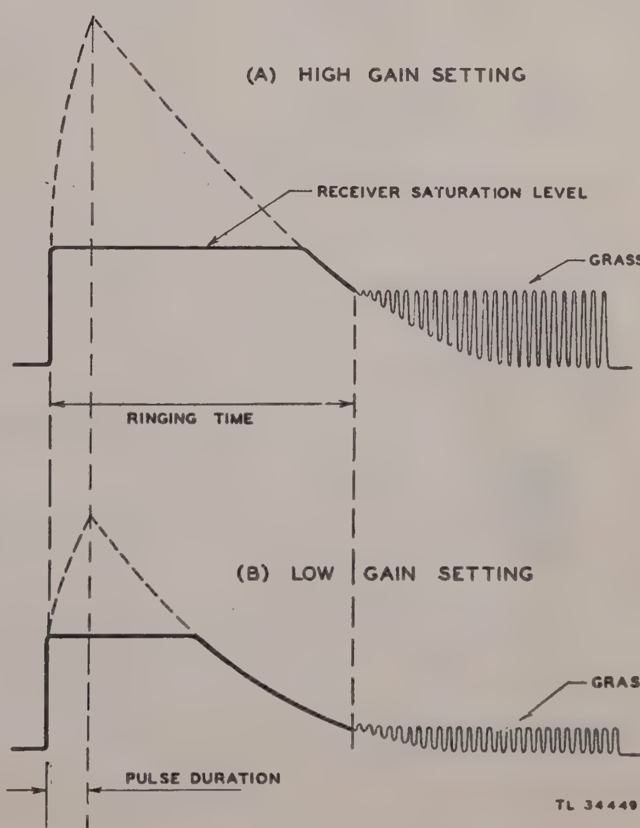


Figure 273. Ringing time measurement.

TABLE III

TEMPERATURE EFFECT OF RINGING TIME FOR A TYPICAL ECHO BOX

Temperature	Change in Ringing Time (Yards)	Temperature	Change in Ringing Time (Yards)
−20°F	+400	+ 60°F	0
+ 0°F	+290	+ 80°F	− 70
+20°F	+180	+100°F	−150
+40°F	+ 70	+120°F	−210

polarization sensitivity, as nearly all ground signals do, the dipole position is important in determining echo strength. Also, most ground signals saturate when the receiver gain is high enough to show noise.

h. Signal-to-noise Ratio. It is important that noise show in performance measurements or in tuning up. Artificial sources of noise, or poor set performance, invariably show up when measuring signal-to-noise ratio, and only by observing this ratio can full performance be achieved.

SECTION II
INSTALLATION AND OPERATION

220. INSTALLATION OF PICK-UP DIPOLE.

a. Location.

(*1*) The pick-up dipole mounted on its support rod is removed from the stowed position; (fig. 275). This assembly is installed in the mounting brackets on the right side of the front end of the trailer (fig. 275). The dipole projects well above the roof of the trailer. The cable connector at the bottom of the dipole support rod must be coupled to the connector on the bottom of the echo box (fig. 269). Figure 275 shows a pick-up dipole in operating position.

(*2*) In order to observe the ringing time on the range scopes more conveniently, provision has been made to connect the echo box near the range scopes. The cable connector at the bottom of the dipole rod is connected to the echo box jack on the switch and data panel (fig. 10) and the echo box is connected to J1989 beside the main rack. Two cables are provided.

b. Positioning of Dipole. In order to couple a maximum amount of r-f energy to the echo box, this pick-up dipole must be parallel with the antenna dipole of Radio Set SCR-784. Thus, the reflector must be positioned so that the radar antenna points directly at the pick-up dipole. The latter should be so oriented that the reflector portion, that is, the tee-section

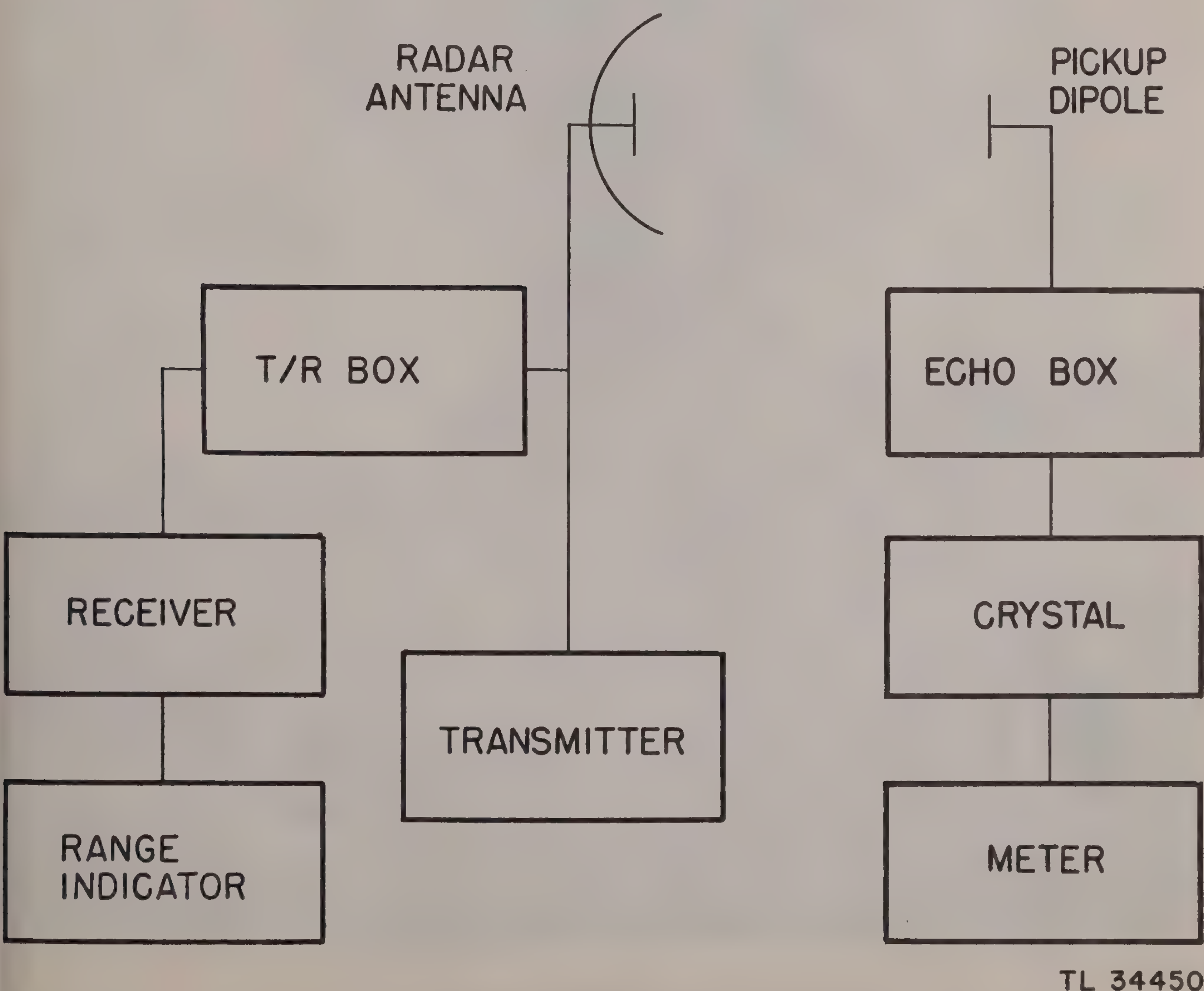


Figure 274. Block diagram for r-f system measurements.

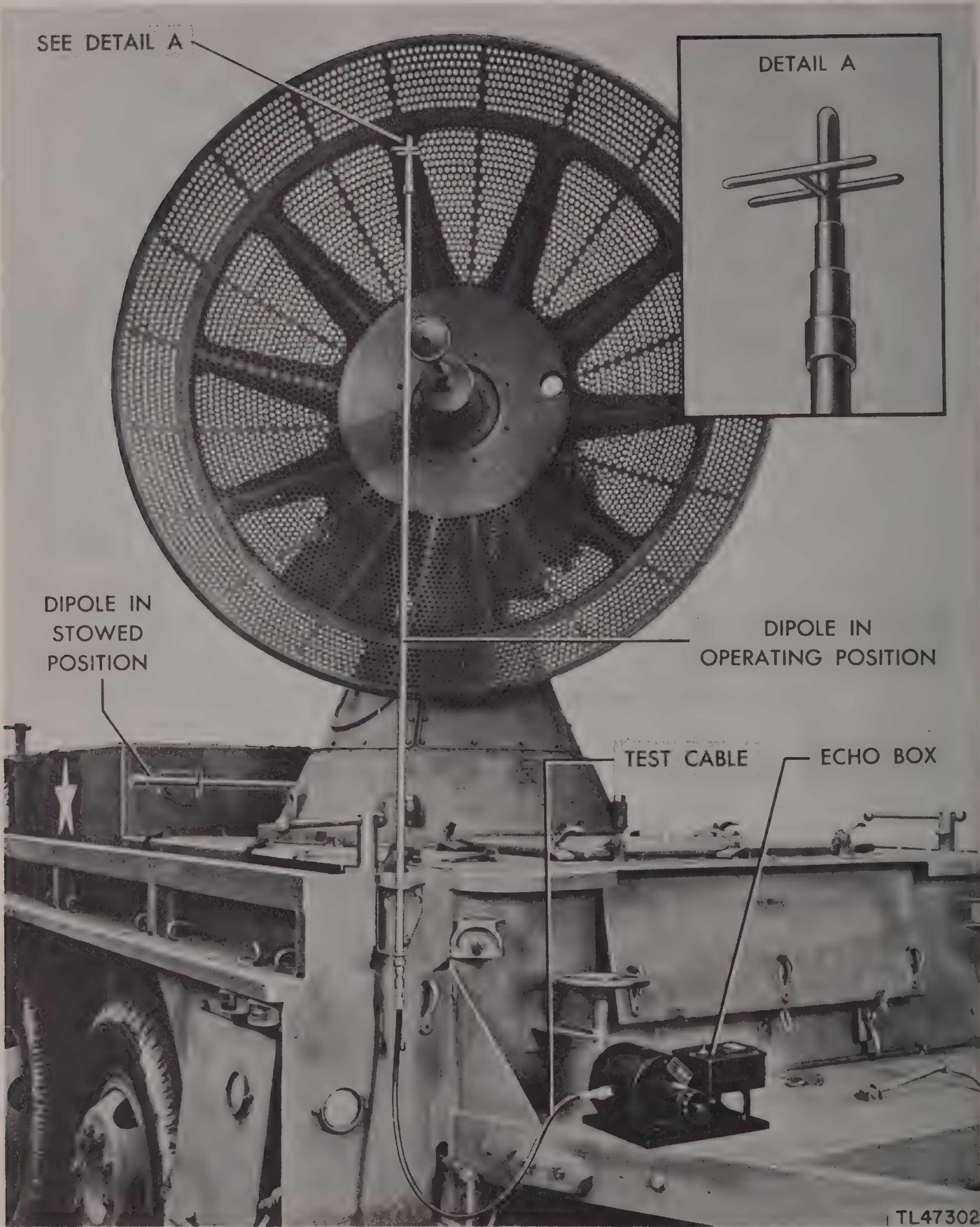


Figure 275. Pick-up dipole in operating position.

which is fastened to the outer conductor, is away from the radar antenna. Then, with the SPINNER MOTOR switch in the OFF position, rotate the radar antenna by hand until the dipole is horizontal. The unpainted section of the plastic cup around the dipole should be uppermost, and inspection through this clear section should reveal the dipole in a horizontal position.

221. OPERATION.

a. Once the echo-box system has been installed in any one Radio Set SCR-784 unit, it is best that none of the parts of that system be exchanged with those of another Radio Set SCR-784. The parts are interchangeable; but system identity should be maintained as nearly as possible to insure repetition of results. Therefore, when the transmitter frequency is changed by replacing the transmitter tube it is necessary to establish a new standard of echo-box radar system performance.

b. Operate Radio Set SCR-784 for 10 minutes before making any echo-box measurements. Figure 274 is a block diagram for use in making r-f system measurements.

SECTION III
RADAR SYSTEM PERFORMANCE MEASUREMENTS

222. R-F SYSTEM TUNE-UP PROCEDURE.

a. Echo Box Tuning.

(*1*) Install the pick-up dipole as outlined in paragraph 220.

(*2*) Put Radio Set SCR-784 in operation with the SPINNER MOTOR switch in the OFF position.

(*3*) Tune the echo box by adjustment of the cavity for maximum deflection on the echo box meter. This tunes the echo box to the frequency of the transmitter. Note the meter reading and the echo-box tuning knob position.

b. R-f System Tuning.

(*1*) Check that the receiver gain is sufficiently high so that noise is seen on the range scopes, and that the receiver AGC switch is in the OFF position.

(*2*) Observe the ringing time on the 32,000- and 2,000-yard range scopes. Even with Radio Set SCR-784 completely out of tune, some apparent widening of the main pulse should be observed as the echo box is tuned to resonance.

(*3*) Manually position the antenna of the SCR-784 in azimuth and elevation for maximum ringing time on the range scopes.

(*4*) Adjust the local oscillator tuning and the local-oscillator reflector voltage for maximum ringing time on the range scopes.

(*5*) Loosen the T-R box tuning-screw locknut and tune the T-R box for maximum ringing time. Lock the T-R box tuning screw in place carefully, using a wrench to tighten the locknut. They must be more than just finger tight. Be sure that the ringing time stays at maximum after the T-R box tuning screws have been locked. It may be possible to retune the local oscillator slightly to still further increase the ringing time.

(*6*) Retune the echo box as outlined in subparagraph **a** above in an effort to obtain a longer ringing time. If it is possible to obtain a still longer ringing time by retuning the echo box, the following investigation should be made. The maximum ringing time observed on the range scopes should coincide with the maximum deflection of the echo-box indicator meter. This may be checked by slowly tuning the echo box through resonance. If the two maximums do not coincide, the system is still not tuned for best performance. This may be explained as follows: With the echo box tuned for maximum meter deflection, it is tuned to the transmitter frequency. If, however, the receiving system, principally the T-R box and local oscillator, is not tuned to the transmitter frequency, the longest ringing time observable on the range scopes will occur when the box is tuned to a frequency between the transmitter and receiving systems. When the box is thus slightly off resonance, the oscillations cannot build up to the highest value during the pulse and the echo-box meter reading is less than maximum. However, the frequency that is sent back to the radar set during the ringing time is more nearly that which the receiver is tuned to accept.

(*7*) Tune the system until the two maximums mentioned in subparagraph (*6*) above coincide.

(*8*) Determine the ringing time by measuring the range to the point where the echo-box signal just begins to join noise (grass). This measurement is independent of the receiver gain as long as sufficient noise is visible. Figure 273 shows why ringing time should not be measured at the saturation level. This measurement would depend upon the receiver gain setting. In measuring the echo-box ringing time, make sure that it is the echo-box ringing time and not a signal or block of signals that is being checked. This can be determined by tuning the local oscillator and noting whether the ringing time goes back and forth. Signals will change in amplitude when this is done, but not in range. The echo-box signal will change in range.

(*9*) To obtain an accurate result, make four measurements of ringing time and average them. By this method ringing time can be measured to at least ±100 yards. If more than one person will be using an echo box and its accessories, these men should practice together so that their measurements of ringing time will agree. Since, for accurate measurements, the receiver gain must be standardized, ringing time should not be observed on the PPI scope.

(*10*) Before proceeding with normal operation of the set, detune the echo box so that no ringing time shows on the range scope. If this is not done, the set will be blocked in the azimuth direction of the echo-box dipole and out to the range of the maximum ringing time.

223. MEASUREMENT OF R-F SYSTEM PERFORMANCE.

a. Install the pick-up dipole as outlined in paragraph 220.

b. Tune the echo box as outlined in subparagraph 222 and manually position the antenna of the SCR-784 in azimuth and elevation for maximum ringing time on the range scopes.

c. Record the value of this ringing time in the log book and check it against values obtained previously.

d. If this reading does not agree to within 100 yards of previous readings, the system performance has changed. It is important to note that a decrease in ringing time of 200 yards indicates that the system is down approximately 3 decibels in performance and that only 85 percent of the maximum effective range of the equipment is obtainable.

224. MEASUREMENT OF TRANSMITTER FREQUENCY.

a. Install the pick-up dipole as outlined in paragraph 220.

b. Tune the echo box as outlined in subparagraph 222 **a** and manually position the antenna of the SCR-784 in azimuth and elevation for maximum deflection on the echo-box meter. Be sure that the center of strongest maximum is read. Two small peaks are usually found on either side of the main peak.

c. Record the scale and knob-tuning position of the echo box. The first two significant figures (0-25) are found by the position of the indicator under the lucite scale on the tuning-knob barrel. The fractional divisions are read off the circumference of the tuning knob itself. Determine the frequency by using the dial division-calibration factor chart. The correct frequency is found by adding 2,700 to the calibration factor. Example: Correct frequency = 2,700 + calibration factor.

225. MEASUREMENT OF TRANSMITTER FREQUENCY SPECTRUM.

a. Install the pick-up dipole as outlined in paragraph 220.

b. Tune the echo box as outlined in subparagraph 222 and tune the r-f system as outlined in subparagraph 222.

c. Record the echo-box dial reading and meter reading as the echo box is tuned slowly through the transmitter spectrum.

d. Plot the meter reading against the dial reading. Figure 276 shows spectrums of a typical system and examples of bad spectrums.

e. In a continuous-wave transmitter the oscillations are at one frequency—the carrier frequency. However, since the radar transmitter output is modulated in the form of pulses, energy will be transmitted in the sidebands—that is, in frequencies above and below the carrier frequency. For square-pulse modulation, the frequency spectrum should be that labeled "good" in figure 276 (a). Since the crystal detector of the echo box is not linear over the entire range, the secondary peaks will be exaggerated. This is an advantage, since deep minimums adjacent to the main peak and a fairly symmetrical curve are indicative of a good spectrum (fig. 276 (a)). For a 2-megacycle bandwidth receiver, the distance between minimums should not be much greater than 2 megacycles, or power will be wasted outside the receiver bandwidth. A "good" spectrum with a low-peak (low-power) meter reading may indicate low voltage or an old transmitter tube. A spectrum without deep minimums adjacent to the main peak is indicative of frequency modulation of the transmitter tube. This may be caused by a voltage pulse whose sides are not steep or whose top is not flat.

f. If two distinct maximums are observed in the spectrum, the transmitter is "double moding", or is being "pulled" in frequency as a result of standing waves in the transmission line. Double moding can often be remedied by adjustment of the line voltage or input voltage to the transmitter. The spacing between two peaks is indicative of the amount of frequency scattering, and the height is indicative of the power radiated in each of the peaks.

226. MEASUREMENT OF LOCAL OSCILLATOR FREQUENCY.

a. In general, measurement of the local oscillator frequency is unnecessary. The tubes are preset to operate within the bandwidth of Radio Set SCR-784. If it is desired to measure

the frequency, take care that the echo box does not "pull" the frequency of the local oscillator. Use a long piece of test cable or join two lengths, so that there is considerable attenuation between the local oscillator and the echo box. It may be necessary to use a short cable to determine the approximate frequency or to determine whether or not the tube is oscillating, and then change to the longer length of cable for actual measurement. In any case, the deflection on the echo-box meter should not be more than one-fourth of full scale when the meter switch is in the most sensitive position and the echo box is tuned for maximum deflection.

b. Remove the echo box and meter from its mounted position in the skirt box.

c. Connect the input of the echo box through an appropriate test cable to the outlet jack J1804 on the front of the local-oscillator panel. Be sure that the connector behind the local-oscillator panel is fastened to the local-oscillator tube. Refer to figure 277.

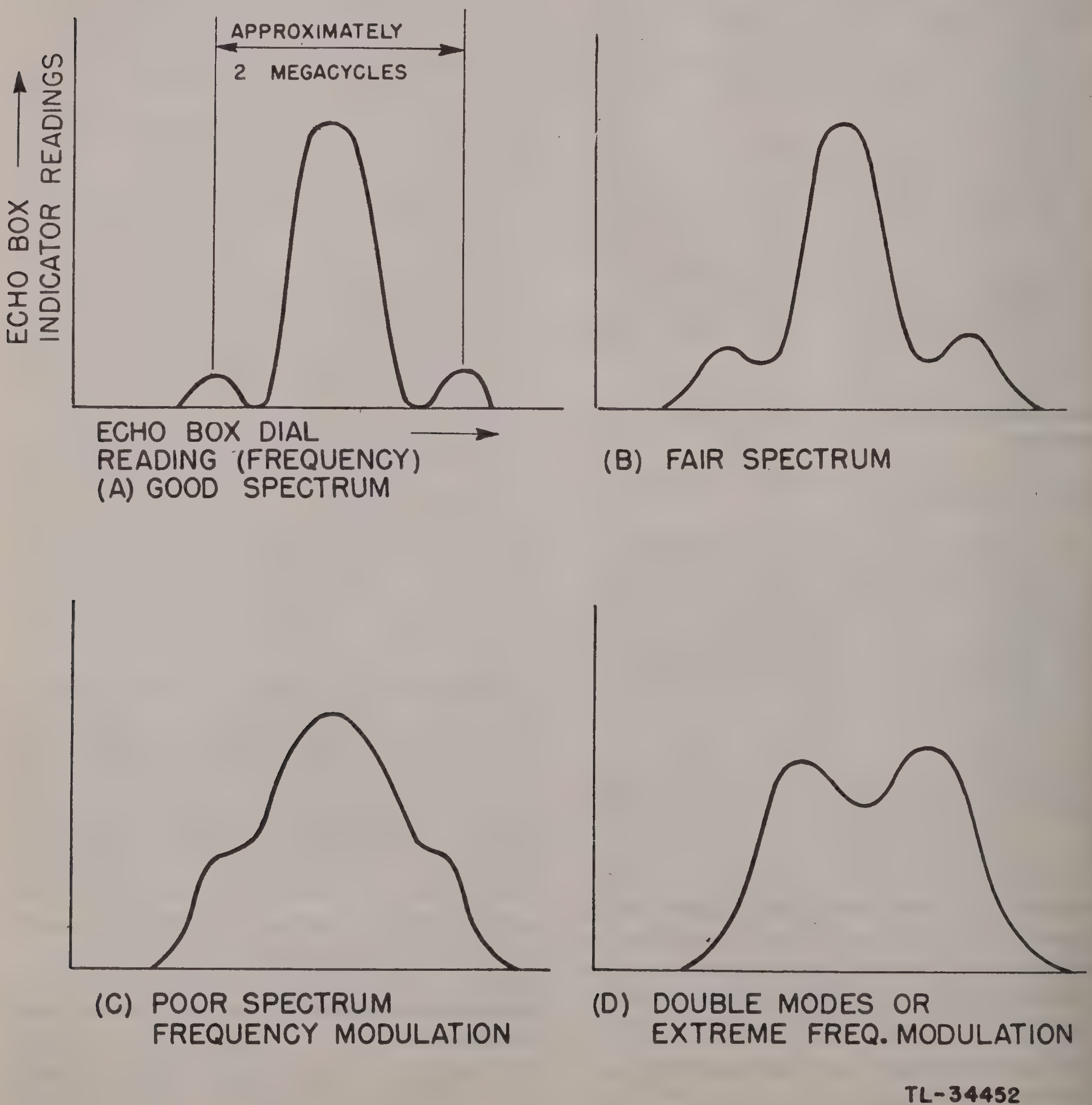


Figure 276. Frequency spectrums.

d. Tune the echo box for maximum deflection on the echo-box meter.

e. Record the scale and knob positions and determine the wavelength by consulting the chart as outlined in paragraph 224.

f. Remove the test cable from the echo box and jack J1804 on the front of the local-oscillator panel and remove the connection from the local-oscillator tube that couples it to the output jack on the front of the local-oscillator panel.

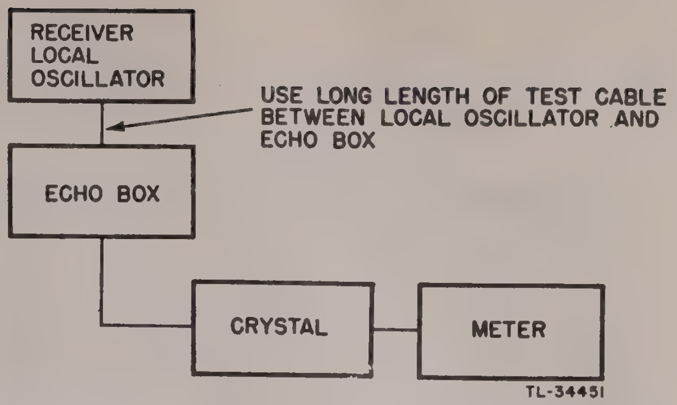


Figure 277. Block diagram for measurement of local oscillator frequency.

SECTION IV
MAINTENANCE

227. GENERAL.

Always stow the dipole and dipole-mounting rod and bracket when they are not in use. This will prevent deterioration of the external cable to the dipole. Install the cap for the feed-through connector when the dipole is stowed.

228. ECHO BOX.

a. If the echo box fails to ring, make the following examinations:

(*1*) Check cables for continuity and shorting.

(*2*) Check center conductor fingers of cable connectors for spreading.

(*3*) Check the coupling loop at the end of the cable from the pick-up dipole. Use the special wrench to remove the loop. Do not remove unless necessary and be careful that no moisture, sand, or grit enters the echo-box cavity.

b. If the echo box rings and shows customary deflection on the range scopes, but the echo-box meter does not give an indication;

(*1*) Remove the indicator box cover and examine the wiring for broken or shorted leads.

(*2*) Replace the crystal, being sure to observe the precautions given in paragraph 229.

229. CRYSTAL.

a. Whenever the crystal is being installed, or is out of its holder, it must be kept away from the transmitting antenna if the latter is radiating. It is best to have Radio Set SCR-784 off the air whenever crystals are removed from their holders. Crystals are quite delicate and should always be wrapped in tinfoil, to protect them from burnout, and if possible they should be stored in metal boxes. In dry climates or in cold weather it is advisable, when inserting crystals, to ground out any static electricity by touching the finger to the echo box before the crystal makes contact.

b. The IN21 crystal is used in the echo box. The IN21 crystal is also used in the mixer of the receiver.

CHAPTER 12
TROUBLE SHOOTING BASED ON STARTING PROCEDURE

230. INTRODUCTION.

Radio Set SCR-784 has been designed carefully to give trouble-free operation, but as in all precision apparatus, faults will occur. The analysis of symptoms and trouble-shooting information which follows has been prepared to aid the repair man in isolating such trouble as may occur, so that the set may be placed back in operation as quickly as possible.

a. The most logical procedure to discover and isolate trouble is to start the set in sequence and then observe carefully all indications until an improper indication appears. In starting the set, the sequence of procedure of TM 11-1354 paragraph 44 should be followed. The information in this chapter is presented in a sequence which follows the steps of the starting procedure. Proper indications are given, as well as most of the improper indications which would indicate trouble occurring at that step of the starting procedure. The explanations of the improper indications are such that, in most cases, the improper indications enable the operator to know quickly in which component the trouble is located and reference should be made to the following chapters of this manual, where more detailed tests and procedures and all reference data are collected by various symptoms.

b. The following paragraphs of normal and abnormal conditions are based on the first 11 steps of the starting procedure.

231. STARTING PROCEDURE, TROUBLE-SHOOTING CHART.

STEP 1. Throw DEHYDRATOR MOTOR switch on the switch and data panel to ON position.

NORMAL INDICATIONS: 1. Motor should be heard running.
2. Pressure gauge should read 3 to 5 lbs per square inch.

ABNORMAL INDICATION	PROBABLE LOCATION OF FAULT
1. No motor noise is heard and pressure gauge reads zero.	1*a*. No power input. Check by turning on switch and data panel light.
	b. Defective cable No. 104 to dehydrator or connections.
	c. Dehydrator controls (par. 254).
2. Motor heard but no pressure indication.	2*a*. Pressure gauge defective. Check by removing bleeder cap in front of dipole and checking air velocity.
	b. Defective compressor (par. 248).
	c. Leaks in r-f line system (par. 242).

STEP 2. Throw main power line switch (fig. 10) on the switch and data panel to ON position.

NORMAL INDICATIONS:
1. The blowers are heard operating.
2. The red light on the receiver power unit is lit.
3. The red light on the altitude converter power unit (if this unit is used) is lit.
4. The red light on the range power unit is lit.
5. The red light on the plan position power unit is lit.
6. The red lights on the range unit, receiver, and automatic tracking unit are lit.
7. The indicator lights on the dials of the antenna position indicator are lit.
8. Line voltmeter indicates.

ABNORMAL INDICATION	PROBABLE LOCATION OF FAULT
1. No normal indications.	1. Defective main line circuit breaker K1901 (fig. 261).
2. Blowers operate, but no lights are lit.	2*a*. Defective voltage regulator (fig. 261). *b*. Defective cable Nos. 83 or 84.
3. Lights are lit, but blowers do not operate.	3. Defective cable 118 or connections.
4. No lights on antenna position indicator and automatic tracking unit.	4*a*. Defective fuses F1904, F1905, or F1906. *b*. Defective cable 3 or 43, or connections.
5. No lights on units in right or left racks.	5*a*. Defective fuses F1901, F1902, or F1903. *b*. Defective cable 88 or 89.
6. Any one light does not glow.	6*a*. Defective bulb in light. *b*. Defective transformer in unit. *c*. Defective fuses adjacent to light or on respective power supply. If fuses are blown locate the cause of the short circuit before replacing. *d*. A-c input cable to defective component.

STEP 3. Depress the LINE VOLTAGE RAISE or LOWER buttons until the LINE VOLTAGE meter reads 115 volts. Check voltage on all three phases by rotating PHASE SELECTOR switch.

NORMAL INDICATIONS:
1. Voltage on all three phases should be 115 $\pm$1 volt.
2. Timebases on range and PPI scopes should appear.

ABNORMAL INDICATIONS	PROBABLE LOCATION OF FAULT
1. LINE VOLTAGE meter reads zero.	1. Defective meter M1751 or switch S1955 (fig. 261).
2. Line voltage cannot be raised or lowered.	2*a*. Defective LINE VOLTAGE RAISE—LOWER switch S1755 or S1756. *b*. Limit switches on line-voltage regulator. *c*. Cable 22 or connections defective. *d*. Defective line-voltage regulator. *e*. Input voltage from power unit too high or too low (110-125).
3. No timebases on range and very dim timebase on PPI scopes.	3. Defective range unit (par. 265).
4. No timebase or spot on PPI scope.	4*a*. Defective PPI power supply (par. 286). *b*. Defective PPI scope.

5. No timebase on PPI scope.	5*a*. Defective PPI unit (par. 288). *b*. Trigger selector control out of adjustment. Rotate until a steady timebase appears on PPI scope. **NOTE:** The trigger selector should be adjusted for proper indications as the set warms up.
6. No timebases on range scopes.	6. Defective range indicator (par. 265).

STEP 4. Press the MODULATOR ON switch S1757 on indicator-control panel.

NORMAL INDICATIONS:
1. White modulator power light is lit.
2. Amber minimum rectifier voltage light is lit.
3. Blowers in transmitter frame assembly can be heard operating.
4. The red light on the local oscillator is lit.
5. Crystal current meter on the receiver panel reads 0.15 to 0.5 milliamperes.

ABNORMAL INDICATIONS	PROBABLE LOCATION OF FAULT
1. No normal indications.	1*a*. Defective cable 21 or connections. *b*. Defective relay K201. *c*. Defective fuses F201 or F202.
2. Normal indications only as long as MODULATOR ON button is held down.	2. Defective holding circuit (fig. 27).
3. Amber minimum rectifier voltage light is not lit.	3. See step 5.
4. Blowers operate but no light or crystal meter indications.	4. A-c input cable to local oscillator.
5. No crystal current.	5. See receiving system trouble shooting (par. 258).
6. Blowers do not operate.	6. Defective blowers or circuit connections (fig. 27).
7. Modulator power light is off.	7*a*. Defective bulb. *b*. Defective control circuit.

STEP 5. If the amber light is not lit, press the RECTIFIER VOLTAGE LOWER button until the amber light comes on.

NORMAL INDICATION: Rectifier minimum voltage amber light comes on.

ABNORMAL INDICATION	PROBABLE LOCATION OF FAULT
1. No normal indication.	1*a*. Defective bulb. *b*. Defective control circuit (fig. 27). *c*. Defective rectifier voltage regulator motor.

STEP 6. Thirty seconds after pressing the MODULATOR ON switch, press the RECTIFIER ON switch.

NORMAL INDICATION: The red RECTIFIER PLATE light on the indicator-control panel lights.

ABNORMAL INDICATION	PROBABLE LOCATION OF FAULT
1. No normal indication.	1*a*. Defective bulb. *b*. Defective fuse F204. *c*. Defective relay K202 (fig. 27). *d*. Time delay relay K205 or interlock circuit across fuses F205 and F206. *e*. Relay K207 chattering.
2. Red light is on as long as the RECTIFIER ON button is pressed.	2. Defective relay K202.

STEP 7. Press and hold RECTIFIER VOLTAGE RAISE button until the RECTIFIER VOLTAGE METER reads 18 to 22 kv. Do not allow the OSCILLATOR PLATE CURRENT meter to exceed 27 milliamperes.

NORMAL INDICATIONS:

1. Amber light goes out.
2. Rectifier voltage meter begins to rise.
3. As rectifier voltage passes 10 kv, the meter dips and then continues to rise. Oscillator plate current shows slight indication.
4. Transmitter main pulse on 32,000-yard range scope.
5. With rectifier voltage at 18 to 22 kv, oscillator plate current, driver plate current, and keyer grid current meters should indicate 20 to 27, 12 to 22, and 11 to 17 milliamperes respectively.

ABNORMAL INDICATIONS	PROBABLE LOCATION OF FAULT
1. No normal indication.	1. Defective high-voltage rectifier motor B201 raise control circuit (fig. 27).
2. Amber light goes out but rectifier voltage remains at zero.	2*a*. Defective meter circuit. *b*. Meter M1753.
3. Step 3 of normal indications does not occur.	3. Switch S201 does not close.
4. No oscillator plate current.	4*a*. Transmitter is not being triggered, see range system trouble shooting (par. 265). *b*. Driver unit (par. 234). *c*. Open high-voltage lead. *d*. Bad meter or film cut-out SG 201.
5. No keyer grid or driver plate current.	5*a*. Defective meter M201. *b*. Film cut-out SG 202.
6. Meter indications not within tolerances when high-voltage rectifier is at 18 to 22 kv.	6. See transmitting system trouble-shooting chart (par. 234).
7. Jumpy or unsteady oscillator current.	7*a*. Arcing in r-f line (par. 243). *b*. Transmitter tuning. *c*. Defective high-voltage rectifier.

STEP 8. Throw the elevation, azimuth, and spinner motor switches on the switch and data panel to the ON position.

NORMAL INDICATIONS:

1. The azimuth and elevation motor generators can be heard running.
2. Dipole can be seen spinning.

ABNORMAL INDICATIONS	PROBABLE LOCATION OF FAULT
1. Azimuth motor generator does not run.	1*a*. Switch S1902 (fig. 261). *b*. Cable 81 or connections. *c*. Motor B1976.

2. Elevation motor generator does not run.	2*a*. Switch S1903 (fig. 261). *b*. Cable 82 or connections. *c*. Motor B1977.
3. Spinner motor not running.	3*a*. Switch S1904 (fig. 261). *b*. Cable connections. *c*. Spinner motor B2056.

STEP 9. Turn CONTROL SWITCH (fig. 202) to AUTOMATIC position.
NORMAL INDICATION: None.

STEP 10. Allow at least 5 seconds for the positioning motors to operate, then turn the CONTROL SWITCH (fig. 202) to the MANUAL position.
NORMAL INDICATION: None.

STEP 11. Set SAFETY switch to RUN position.
NORMAL INDICATIONS:
1. Antenna should not move.
2. Meters of azimuth and elevation tracking unit indicate if key switch under meters is in azimuth or elevation position.
3. Meter on automatic tracking unit indicates.

CAUTION: If antenna slews, turn SAFETY switch to STOP position.

ABNORMAL INDICATIONS	PROBABLE LOCATION OF FAULT
1. Antenna slews continuously in azimuth.	1*a*. Azimuth channel in azimuth and elevation tracking unit (par. 296). *b*. Open control field of azimuth servo generator exciter. *c*. Defective azimuth selsyn transformer in pedestal.
2. Antenna slews in elevation and jams against stop.	2*a*. Elevation channel in azimuth and elevation tracking (par. 296). *b*. Open control field in elevation servo generator exciter. *c*. Defective elevation selsyn transformer. **NOTE:** To release jam of elevating mechanism loosen elevation drive motor mounting bolts and slide motor out about 1/32 of an inch. The spring of the stop will release the gear train; replace motor, and tighten bolts.
3. Antenna jams in elevation as handwheel is turned.	3*a*. Defective limit switch in elevation selsyn compartment (par. 166). *b*. Defective rectifier unit CR-1901 in switch and data panel.
4. Antenna slews considerably and then comes to rest.	4. Defective follow-up motor circuit of AP control unit (par. 296).
5. Antenna moves or drifts in azimuth or elevation.	5*a*. Residual magnetism in a motor generator. This will remedy itself after the antenna has been operated under manual control. *b*. Antenna position system needs alignment (par. 297).
6. Meters do not indicate.	6*a*. Safety relay circuit defective (fig. 191). *b*. Power supply section of automatic tracking unit (fig. 212).

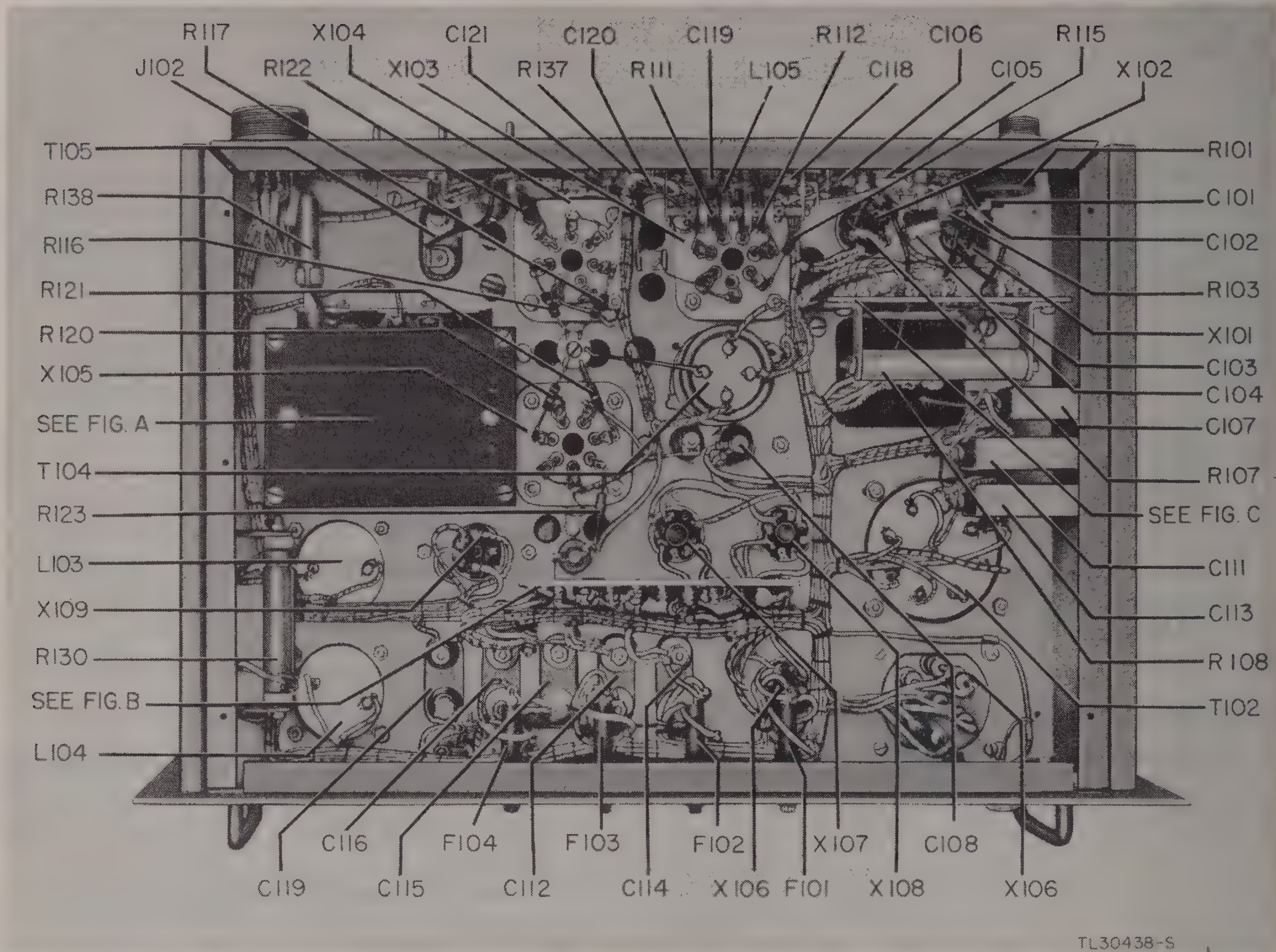


Figure 278. Driver unit, bottom view, parts identified.

CHAPTER 13

TROUBLE SHOOTING IN THE TRANSMITTING SYSTEM

WARNING: *Voltages, sufficiently high to cause death on contact, are exposed at many points in the transmitter frame assembly. Do not place hands within the unit with the high voltage on. Do not make any connections into the unit which bring high voltage out to an exposed point. Make all tests with the high voltage off. Always ground high-voltage capacitors before touching them or their associated circuits.*

232. REFERENCE DATA.

In trouble shooting the transmitting system, refer to the following figures for schematic diagrams, voltage and resistance readings, and identification of parts:

a. Figure 29. Transmitter system, complete schematic diagram.

b. Figure 27. Transmitter control circuits.

c. Figure 28. Driver, complete schematic diagram.

d. Figures 278 to 284. Identification of parts.

233. GENERAL TROUBLE-SHOOTING PROCEDURE.

a. Control Circuits. Faults in the transmitter control circuits are isolated by going through the starting procedure and observing the action of the relays as described in paragraph 32. Remove the panels which cover the relays, and short out the interlock switches by pushing in on interlock switch and turning clockwise. Start the equipment. When a relay does not operate as described, trace the circuit with an ohmmeter.

b. Driver, Modulator, and Rectifier Circuits. Troubles can be traced to any of these components by the use of the test jacks and by the voltage and current meters on the panels. The symptoms given in the trouble-shooting chart cover the external indications of trouble. Monitoring jacks J101, J201, and J202 provide means of measuring the trigger input to the driver unit, the driver output pulse, and the keyer output pulse respectively. The appearance of these pulses gives a good indication of the over-all performance of the components.

(*1*) *Measuring Modulator Input Voltage.* Built-in capacity voltage dividers and attenuators are provided in the modulator to reduce the high voltages present at the grid and output of the keyer tubes to a value suitable for measurement on the cathode-ray oscilloscope provided with the equipment. The voltage as measured at jack J202, on the front of the transmitter frame assembly (fig. 20) is the keyer grid input. Plug the test cable into jack J202. Reduce the horizontal (sweep) gain control to zero after noting carefully the position of the zero voltage line on the screen. Operate the equipment for normal output. The peak amplitude of the pulse is indicated by a faint vertical line extending above and below the zero-voltage point. Care must be taken to avoid leaving the picture on the screen longer than necessary to take the reading and the measurement. The upward deflection (positive) above the zero voltage line, should correspond to the following:

> Positive deflection in inches x screen sensitivity (volts per inch) x capacity-divider multiplying factor of 100 equals 2,400 to 3,225 volts.

The downward deflection (negative) calculated in similar manner should correspond to –500 to –750 volts.

(*2*) *Measuring Modulator Output Voltage.* The modulator output or oscillator plate voltage (peak) may be observed by plugging the oscilloscope test cable into jack J201, at the front

of the transmitter frame assembly. The procedure for calculating the keyer grid voltage should be followed except that the capacity-divider multiplying factor will be 400. The pulse is maximum in the downward (negative) direction, and in general, should be 1,000 to 4,000 volts less than the voltage reading of the high-voltage rectifier meter. The pulse in the positive direction should be 2,000 to 3,000 volts.

234. TRANSMITTER SYSTEM, TROUBLE-SHOOTING CHART.

A. SYMPTOMS:
1. Only timebase and grass visible on the scopes.
2. OSCILLATOR PLATE CURRENT reading zero.
3. KEYER GRID CURRENT and DRIVER PLATE CURRENT readings zero.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. No trigger pulse reaching transmitter system.	1. Check for 10-17 volt trigger pulse at jack J103. If trigger is not present, check continuity of cable from range unit. Refer to range unit trouble shooting (par. 265).
2. Driver unit.	2*a*. Check for driver output pulse at jack J202 (par. 233). *b*. Remove driver. Connect jack J102 to P102 using test cable W212. Do not connect terminal board TB101 or jack J101. Turn the modulator on. Make voltage checks on the driver components and compare them with the voltages on the driver voltage and resistance chart (fig. 280). *c*. Turn power off. Make resistance checks on driver components and compare with those of the voltage and resistance chart (fig. 280).

B. SYMPTOMS:
1. Only timebase and grass visible on the scopes.
2. OSCILLATOR PLATE CURRENT reading zero.
3. KEYER GRID CURRENT reading zero.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Modulator unit.	1*a*. Check for modulator output pulse at J201 (par. 233). *b*. Turn power off and make continuity and resistance checks in the modulator. Compare results with the readings in the modulator voltage and resistance chart (par. 240). *c*. Replace tubes V203 and V204.
2. Keyer bias supply.	2*a*. Check for –565 volts at plug P209. *b*. Replace tubes V210 and V211.

C. SYMPTOMS:
1. Only timebase and grass (or weak signals) visible on the scopes.
2. OSCILLATOR PLATE CURRENT less than 20 ma.
3. RECTIFIER VOLTAGE less than 18 kv.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. High-voltage rectifier.	1*a*. Press LOWER button until the voltage regulator has been reduced to its minimum position, thus turning off the high voltage. The

amber minimum rectifier voltage light should go on. Observe tubes V201 and V202 to see that they are lighted.

b. Test for 115 volts ac between terminals 1 and 2 on transformer T201.

c. Turn the main power line switch on the switch and data panel to the OFF position. Make resistance and continuity checks in the high-voltage rectifier components. Compare the measurements with those of the voltage and resistance chart (par. 240).

D. SYMPTOMS: 1. Main pulse about 1½ times as wide as normal.
2. KEYER GRID CURRENT reading too high.
3. DRIVER PLATE CURRENT reading too high.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Delay line.	1. Turn power off and check for open delay line in the driver unit (fig. 278).

E. SYMPTOM: Trailing edge of main pulse shows oscillations.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Damping diodes.	1*a*. Check to see if tubes V207, V208, and V209 are lighted. *b*. Check continuity of transformer T208 and filament circuit of damping diodes.
2. Meter circuit.	2. Check to see that coil L202 and damping diodes are grounded through jack J207, cable 73, jack J1756, and meter M1752.

F. SYMPTOM: Solid base line under main pulse.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Arcing in magnetron or r-f line.	1. Turn power off and check for signs of arcing in the magnetron or r-f line.
2. Driver.	2. Check amplitude of driver output at jack J202. A weak trigger causes intermittent operation of the modulator. If improper functioning of the driver stages is indicated, trouble-shoot the stages according to the instructions in symptom A, 2.
3. Modulator.	3. Check modulator according to the instructions in symptom B, 1. A weak trigger may be caused by a fault in the modulator grid input circuit.

G. SYMPTOM: KEYER GRID CURRENT less than 11 ma.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Low emission driver output tubes.	1. Measure peak voltage at jack J202. If it is less than 2,500 volts, replace V104 and V105. If the peak voltage at jack J202 is more than 3,000 volts, refer to 3 below.
2. Open screen or plate resistors in the driver tubes.	2. Check R113, R114, R115, R118, R119, R122, R123, R124, and R125 (fig. 278).
3. Low emission modulator tubes.	3. Replace tubes V203 and V204.
4. Open plate resistors in the modulator tubes.	4. Check R210 and R211.

H. SYMPTOM: Main pulse too wide, trailing edge variable.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Modulator input circuit.	1. Check coil L203 and capacitor C204 for open circuit.

235. ADJUSTMENTS AND ALIGNMENT.

a. Relay Adjustments. The following adjustments should be made to set the relays in the transmitter frame assembly to operate at the proper time.

(*1*) Set relay K203 (knob marked K203 TRIP ADJUSTMENT) to approximately 50.

(*2*) Set relay K207 (knob marked K207 TRIP ADJUSTMENT) to approximately 50.

b. Cam Adjustments.

> **CAUTION:** Turn off power and short capacitors C201, C202, C203, and C207 to ground before making any cam adjustments.

(*1*) The cams should not normally require adjustment and should not be changed in position unless trouble is isolated to them. When observing the cams for normal operation, the following action can be seen:

(*a*) The cam of S212 closes switch S212 when transformer T201 is approximately 10° from the extreme counterclockwise position.

(*b*) The cam of S203 opens switch S203 approximately 5° later than switch S212 when transformer T201 is being rotated toward the extreme counterclockwise position.

(*c*) The cam of S202 opens switch S202 when transformer T201 is approximately 20° from the extreme clockwise position.

(*d*) The cam of S201 closes switch S201 when transformer T201 is approximately 1/3 of the way between counterclockwise and clockwise.

(*2*) The cams should first be adjusted to the approximate positions given above. The final adjustments should be made by noting the action under operating conditions, then turning off the power and adjusting the cams as follows:

(*a*) Adjust the cam for S201 so that the DRIVER PLATE CURRENT meter starts to read when the RECTIFIER VOLTAGE meter reads 10 kv.

(*b*) Adjust the cam for S202 so that switch S202 opens when the RECTIFIER VOLTAGE meter reads 24.5 kv. Under no condition should the rectifier voltage be raised above 24.5 kv.

(*c*) Adjust the cam for S203 so that switch S203 opens when the RECTIFIER VOLTAGE meter reads zero.

(*d*) Adjust the cam for S212 so that switch S212 opens when the RECTIFIER VOLTAGE meter reads 3 kv.

c. Field Adjustment of Transmitting Oscillator. The field magnet of the transmitting oscillator is provided with a variable air gap in which the oscillator is mounted. The setting of this gap should be adjusted each time a new oscillator shows that it is not operating at a stable point. The criterion of correct adjustment is a steady oscillator plate current indication over a range of about 4 kv variation of the high voltage. The adjustment is, in general, quite broad. The recommended procedure is:

(*1*) Place the SCR-784 in normal operation up to step 7 of the starting procedure (raising the high voltage).

(2) Increase the high voltage to 18 to 22 kv. An oscillator plate current of 20 to 25 ma should be indicated and the main pulse should appear on the 32,000-yd range scope. In no case allow the current to rise above 27 ma.

(3) Observe the oscillator plate current for steadiness of the indication. Vary the gap adjustment cautiously to improve the steadiness of the current indication. Counterclockwise rotation of the control increases the current. The steadiness that is desired is freedom from sharp and continual flickering which is not accompanied by corresponding unsteadiness in the line voltage. Most oscillators have a good operating point at approximately 19.5 kv and 25 ma.

(4) After the adjustment has been set, the high voltage should be varied from 18 kv to approximately 22 kv and the oscillator plate current observed for smooth variation with the high voltage, and freedom from sharp changes and flickering. The normal values of current and voltage are 26 ma and 22 kv, and should not be exceeded.

(5) Return the high voltage to approximately the middle of the range indicated in (2) above and the adjustment is completed.

236. REPLACEMENT OF MAGNETRON (fig. 24).

> **CAUTION:** Do not lift or hold the magnetron by the filament leads. Remove wrist watches while working near the magnet or they will become magnetized. Screwdrivers and wrenches should be held with a firm grasp to prevent the magnet from pulling them from the repairman's hand. Do not strike the magnet. To do so may disturb its field pattern and reduce its strength.

a. Make certain that the modulator and high-voltage rectifier are shut down.

b. Remove L-shaped cover at the rear of the middle section of the transmitter frame assembly.

c. Remove filament leads from magnetron.

d. Loosen the coaxial line standard coupling between the tee-junction and the magnetron. Do not loosen the knurled ring on the magnetron.

e. Slide the magnetron and its mounting plate out from the mounting bracket to the right. Do not pull the magnetron out until the bullet has cleared the transmission line.

f. Remove the knurled coupling ring from the magnetron.

g. Remove the magnetron from the mounting plate.

h. Mount the new magnetron on the mounting plate.

i. Install a gasket in the new tube and place the fitting over the output seal. Tighten the knurled ring.

j. Slide the new oscillator into place. Exercise care so as not to damage the tube. Make sure that the bullet connector makes good contact with the magnetron output lead.

k. Replace the thumbscrews that hold the mounting plate.

l. Replace screws into the standard coupling. Make sure that the gasket is correctly placed.

m. Connect the magnetron filament leads.

n. Replace the cover at the rear of the transmitter frame assembly.

o. Place into operation. Watch the OSCILLATOR PLATE CURRENT meter carefully as the voltage is brought up. The current should not exceed 27 ma. Listen for possible arcing at the output lead or in the magnetron.

p. Turn the field adjustment as explained in paragraph 235**c**.

> **CAUTION:** The high-voltage lead to the magnetron is not covered. Do not come in contact with this lead when making tuning adjustments.

237. AGING OF MAGNETRON TUBES.

Before placing in operation a new magnetron tube or a magnetron tube that has been inactive for two weeks or more, the following aging procedure is recommended:

Current	*Aging Cycles*	*Steady Operation Periods*
Set magnetron current to:	Run for 25 sec. Snap off hv for 5 sec. Repeat. Period of:	After proper number of aging cycles, run steadily for 1 min, then advance 5 ma and repeat aging.
12 ma	2 min (4 cycles)	1 min
17 ma	2 min (4 cycles)	1 min
22 ma	3 min (6 cycles)	1 min
27 ma	2 min (6 cycles)	Tube may now be operated continuously.

Because of slight differences in characteristics of different manufacturers' tubes, it is not always possible to adjust for the normal full-power condition of 27-ma oscillator plate current with 22-kv rectifier voltage. It may be necessary to decrease the field magnet gap to minimum and decrease the rectifier voltage to 21 or 19 kv to maintain the normal oscillator plate current of 27 ma.

238. INSPECTION OF MAGNETRON TUBE OUTPUT PIN.

It is very important that the tungsten output pin of the magnetron tube be kept clean at all times. The bullet must be checked after every 150 hours of operation to make certain that the fingers are tight and the contact surfaces are free from oxidation. If the metal is discolored or dirty, it should be cleaned.

239. CHANGING MODULATOR TUBES.

When new 6C21 modulator tubes are installed in the modulator, it is recommended that they be seasoned in accordance with the following instructions:

a. Disconnect the oscillator filament leads and tape and tie them so that their lugs are not touching each other and are well away from the inclosure cover.

b. Operate the modulator in the normal way, but raise the high voltage to 24.5 kilovolts.

c. If the overload relay trips, reapply the power and continue operation until the modulator will operate for two or three minutes without the overload relay tripping.

d. Shut off the high voltage and reconnect the oscillator for normal operation.

240. VOLTAGE AND RESISTANCE CHART FOR MODULATOR, HIGH-VOLTAGE POWER SUPPLY, AND LOW-VOLTAGE POWER SUPPLIES.

Test Points (to ground unless otherwise stated)	*Condition*	*Resistance*	*Voltage*
C205		12.5 megohms	
Coil L202 terminal 2		22,200 ohms	
Between filament terminals (pins 1 and 4) on V201, V202, V205, V206, V207, V208, V209	Make sure that all door interlocks (S204-S210) are open; short all capacitors to ground with shorting tool; make sure that K204 is not energized.	2-4 ohms	5v ac
Between filament terminals (pins 1 and 4) on V203 and V204	Observe all precautions listed above.	2-4 ohms	6.3v ac
P030 to P031 (magnetron filament)	Observe all precautions listed above. Adjust R223 for correct filament voltage.	2-4 ohms	8v ac
P209		4 megohms	–565v dc
Terminal 1 to terminal 2 on T201	Movable arm of T201 in minimum voltage position. Interlocks (S204-S210) open.		115v ac
Terminal 1 to terminal 3 on T206		1-3 ohms	

Test Points (to ground unless otherwise stated)	*Condition*	*Resistance*	*Voltage*
Terminal 5 to terminal 7 on T206		615 ohms	
Terminal 1 to terminal 7 on T210		1-4 ohms	
Terminal 8 to terminal 10 on T210		440 ohms	
V201, plate	K206 closed	155 ohms	
filament		infinite	
V202, plate		infinite	
filament	K206 closed	200 ohms	
filament	K206 open	12 megohms	
V203 and V203	K206 closed		
grid		20K ohms	
filament		0	
plate		10.5K ohms	
V205 and V206	K206 closed		
filament		2 megohms	
plate		2 megohms	
V207, V208, and V209	K206 closed		
filament		0	
plate		infinite	
V210 and V211	K206 closed		
filament		1.5 ohms	
plate		480 ohms	

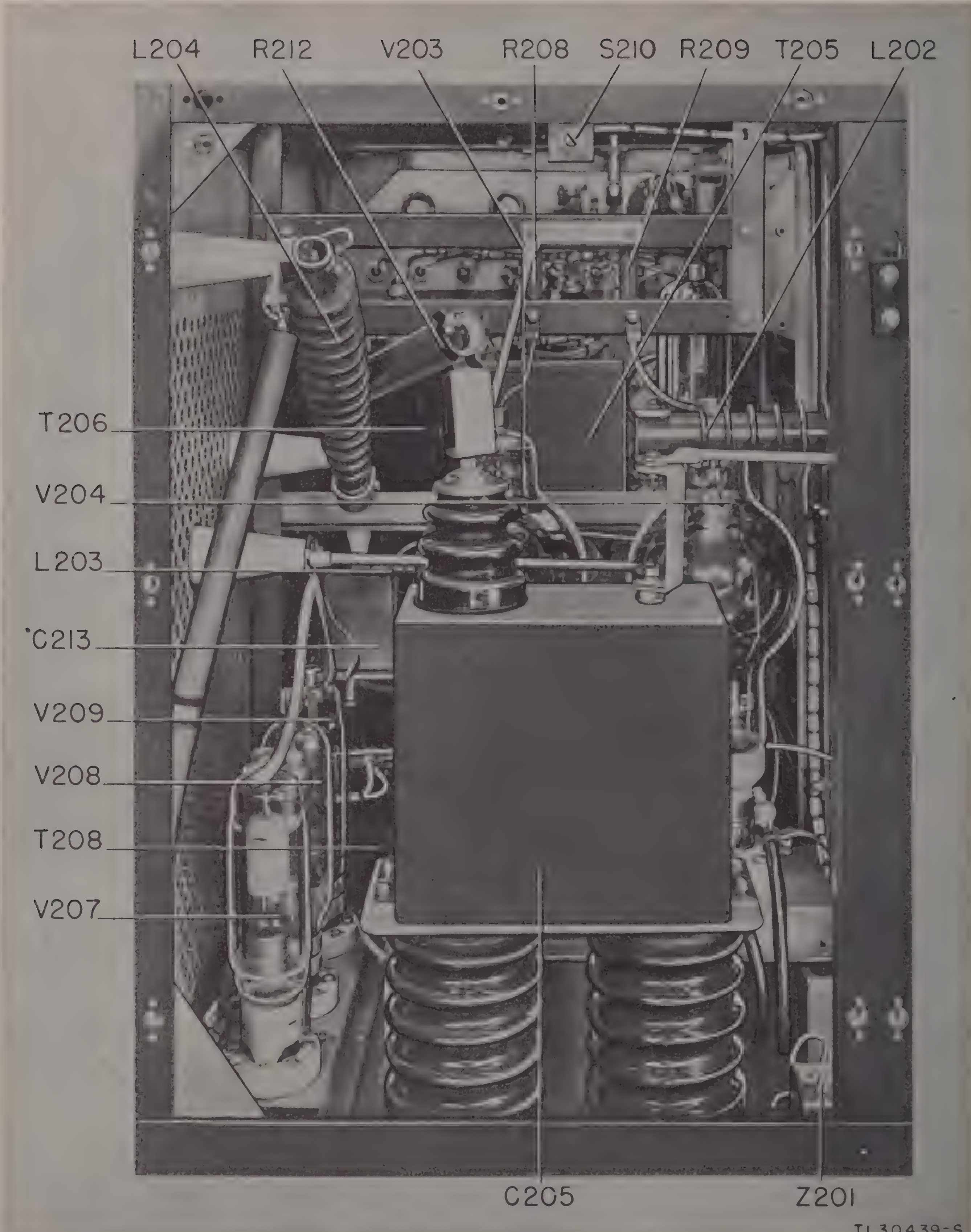
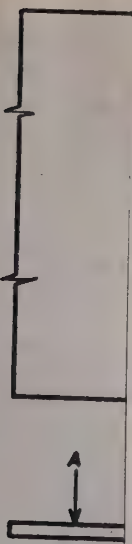


Figure 279. Modulator section, rear view, parts identified.



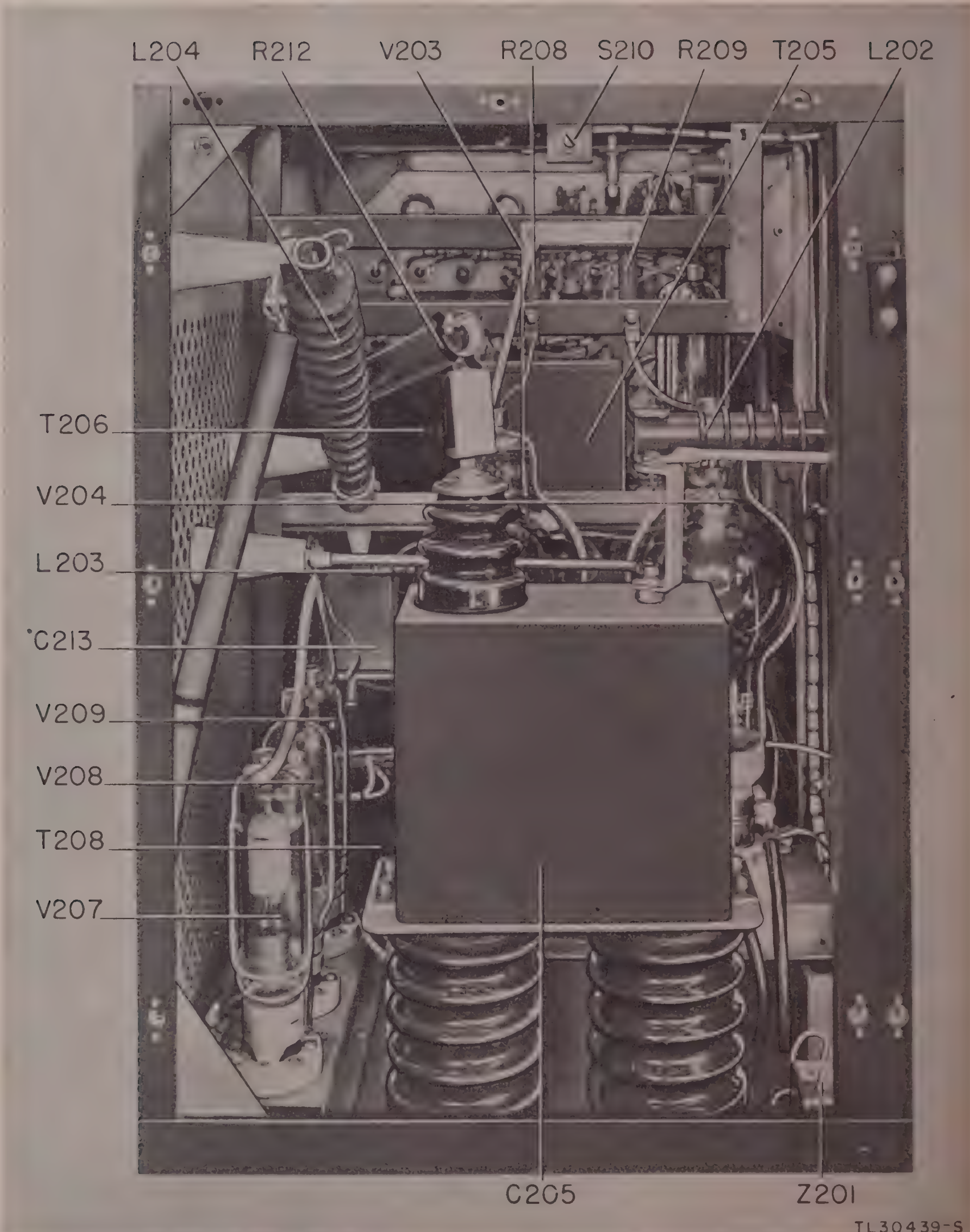


Figure 279. Modulator section, rear view, parts identified.

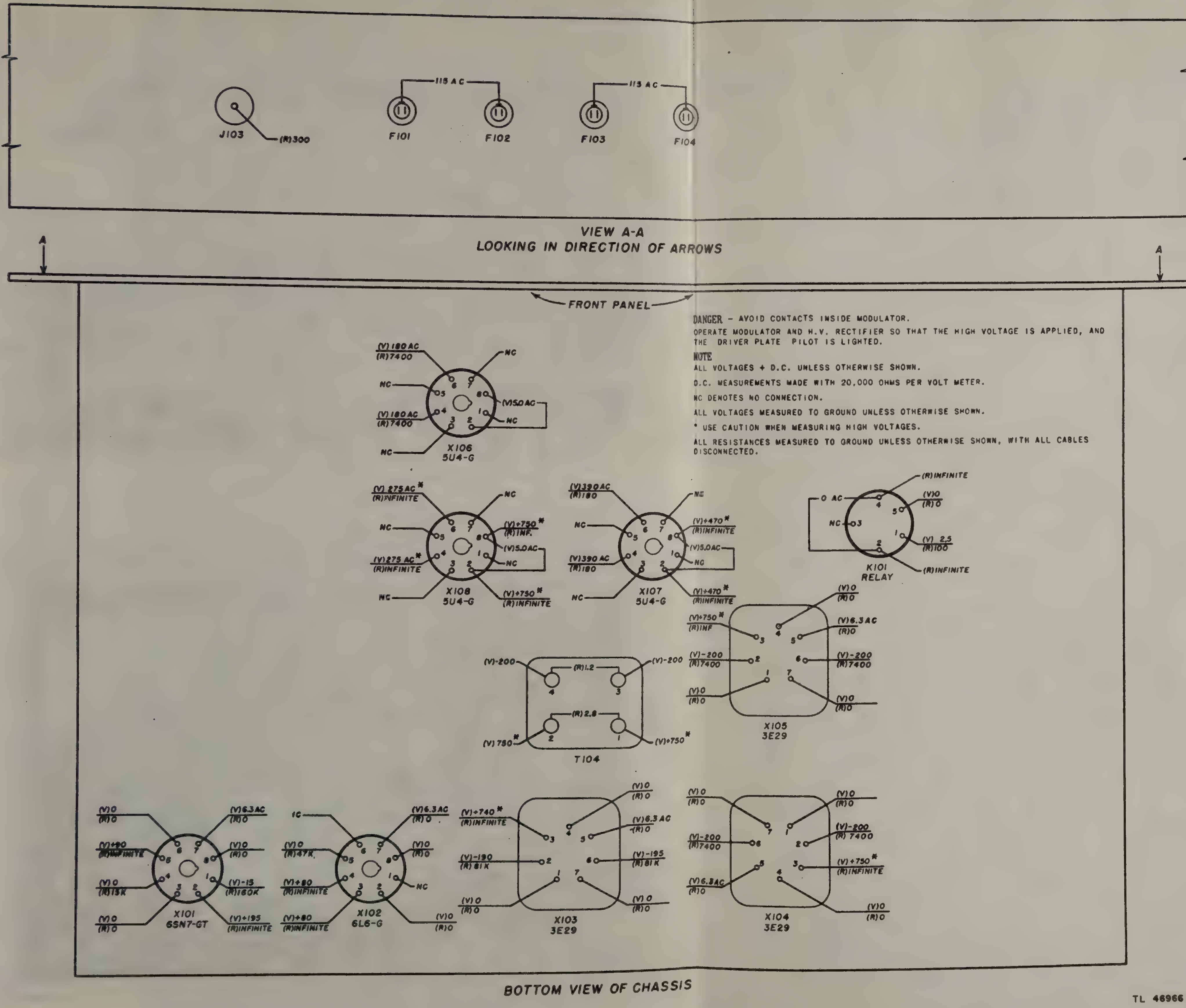


Figure 280. Driver unit, voltage and resistance chart.

Figure 280. Driver unit, voltage and resistance chart.

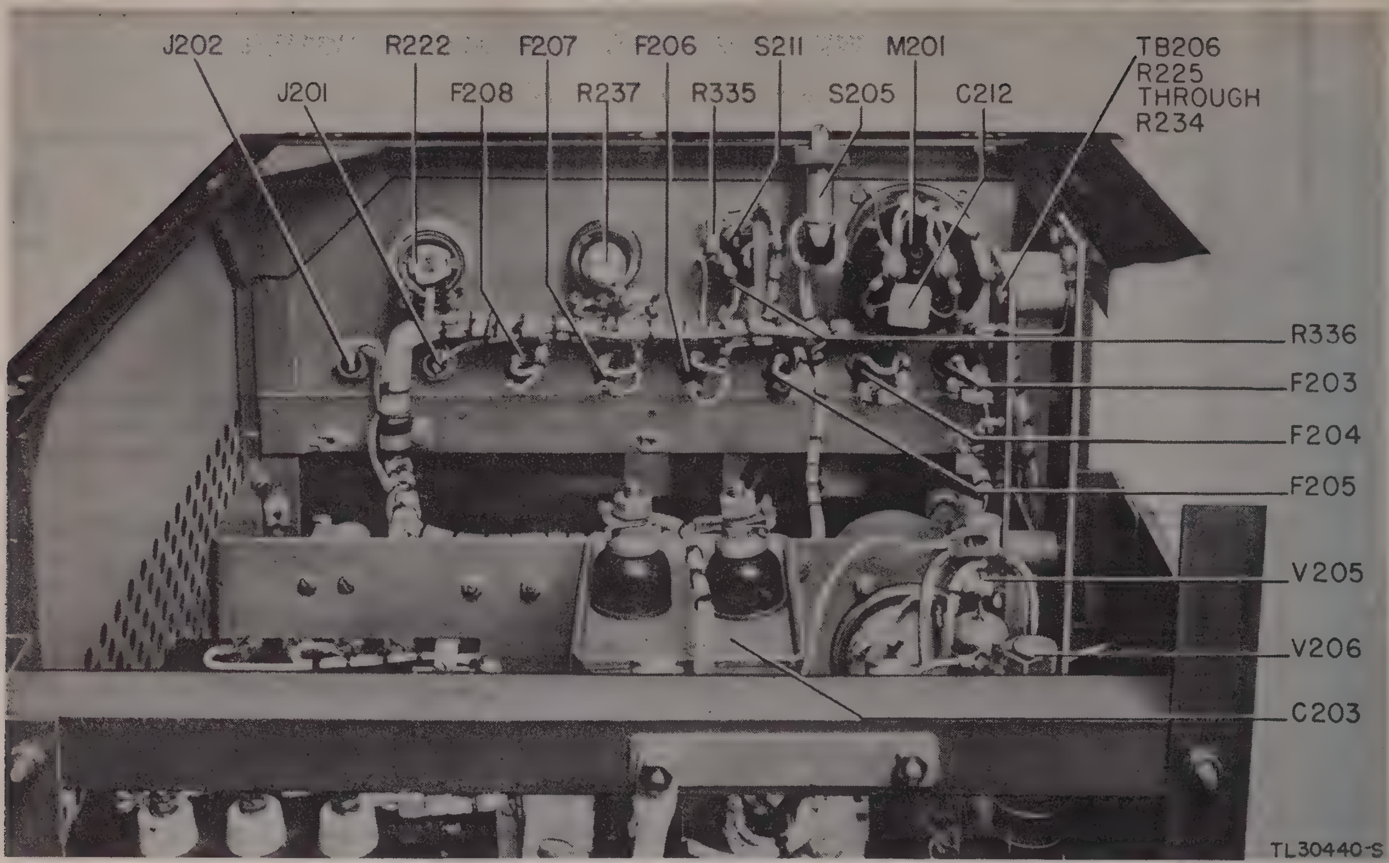


Figure 281. Meter control panel, rear view, parts identified.

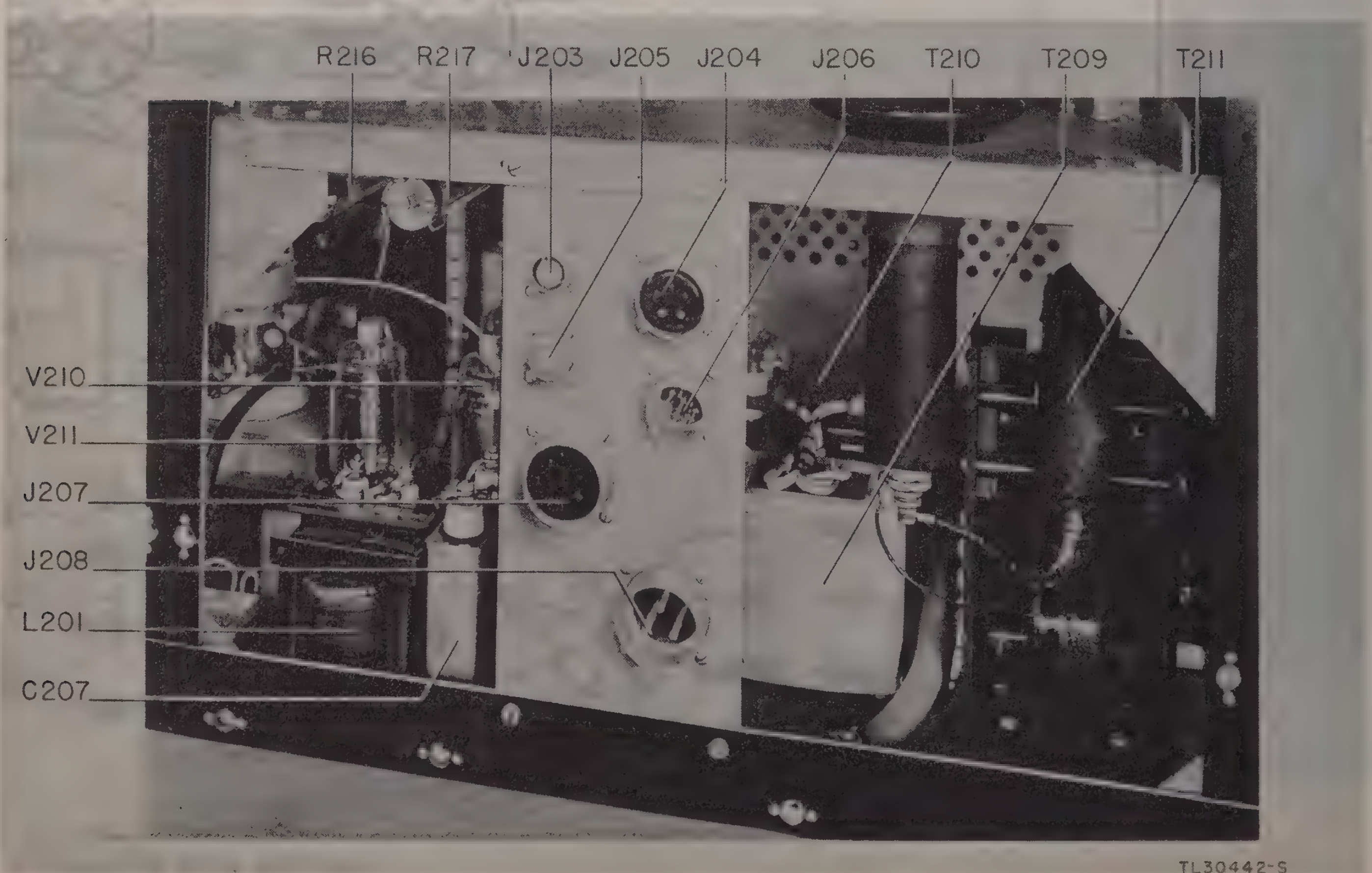


Figure 282. Transmitter, lower panel, parts identified.

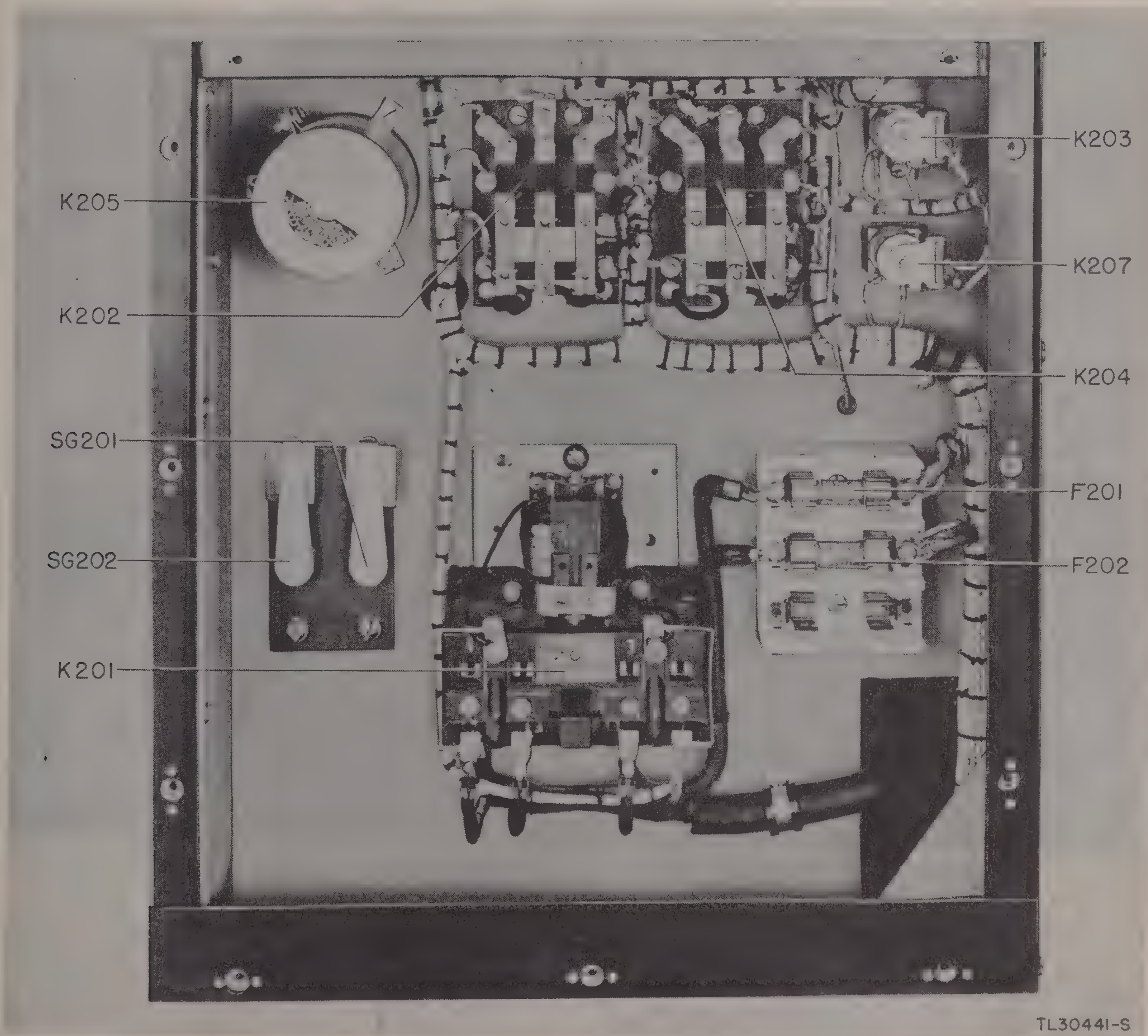


Figure 283. Relay panel, front view, cover removed, parts identified.

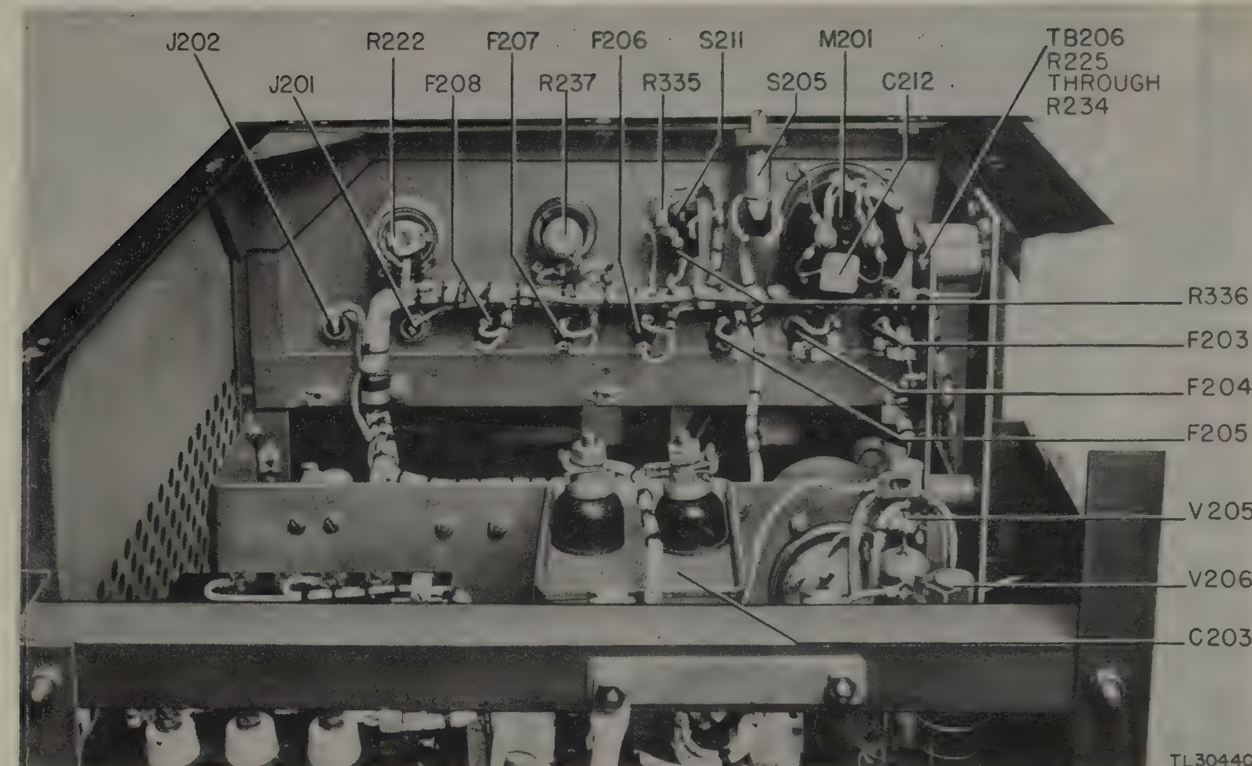


Figure 281. Meter control panel, rear view, parts identified.

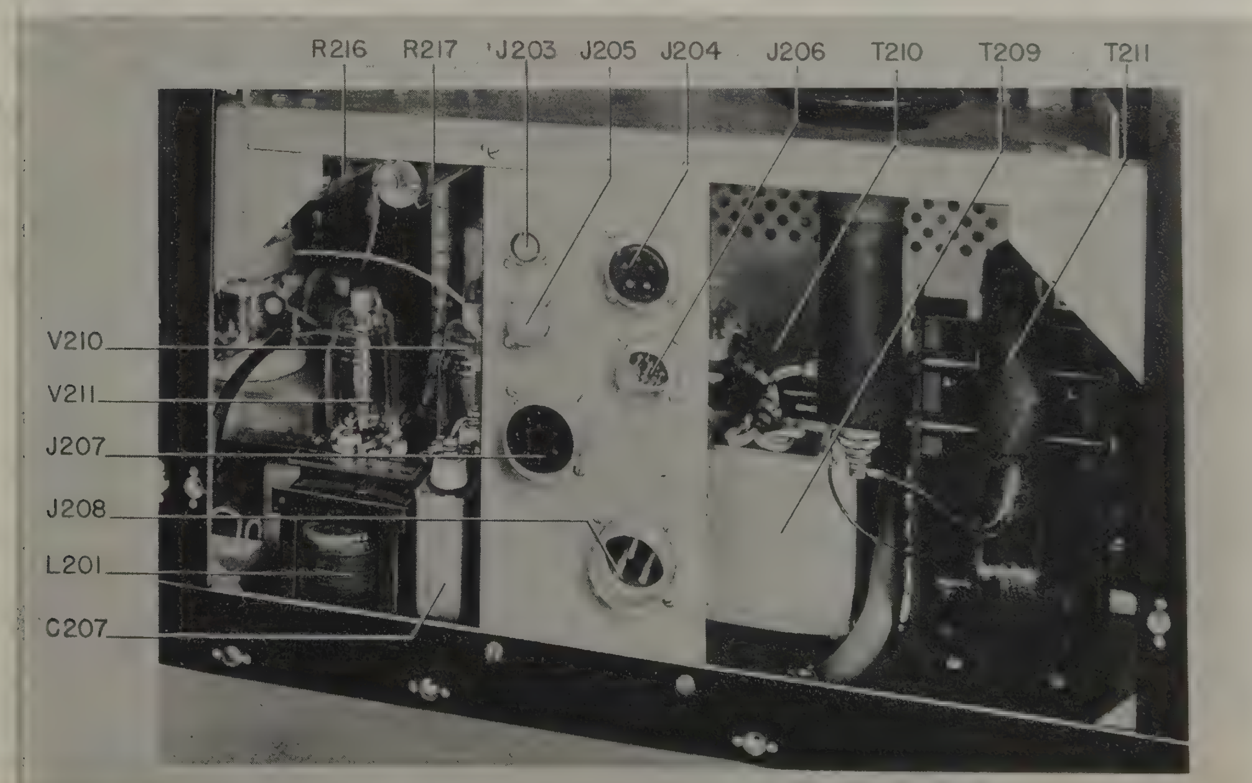


Figure 282. Transmitter, lower panel, parts identified.

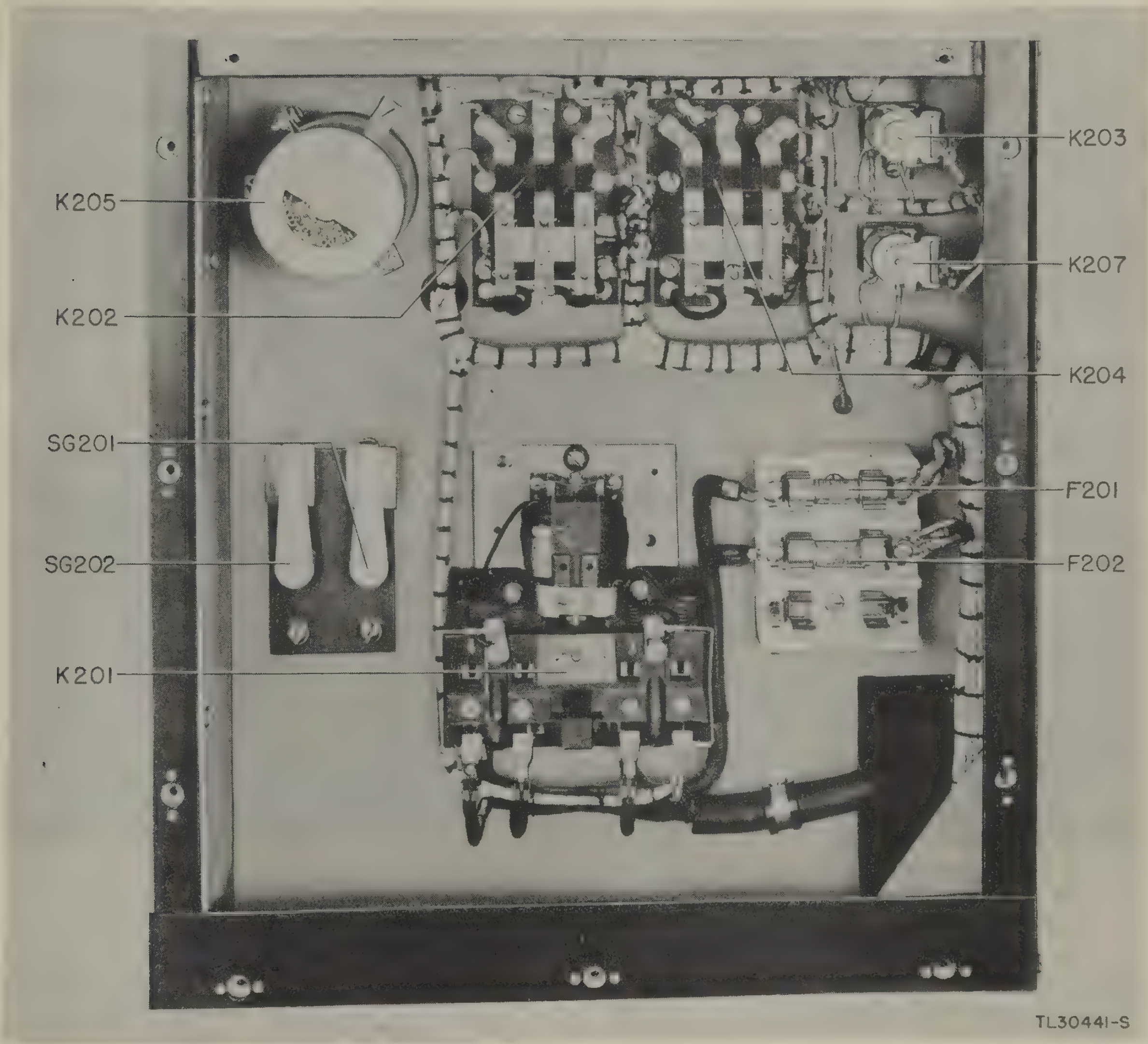


Figure 283. Relay panel, front view, cover removed, parts identified.

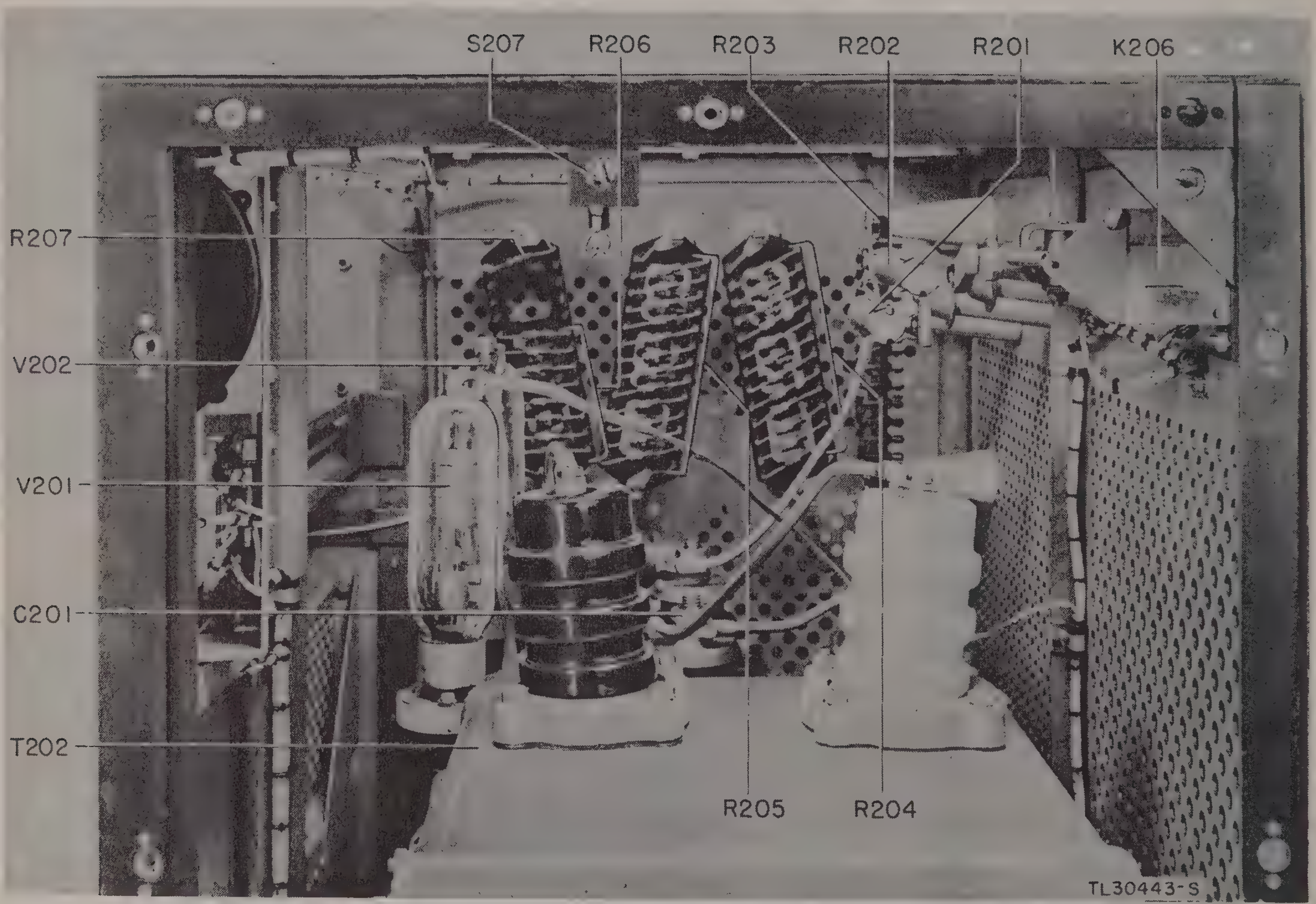


Figure 284. High-voltage rectifier section, parts identified.

CHAPTER 14
TROUBLE SHOOTING IN THE R-F SYSTEM

SECTION I
R-F LINES

> **WARNING:** *Voltages sufficient to cause death on contact exist in the r-f system. Special care must be taken while working near the transmitting oscillator, the T-R box, and the local oscillator. Do not make any connections which will bring high voltage out to an exposed point. When possible, make tests with the high voltage off.*

241. REFERENCE DATA.

The following reference data is included to assist in trouble shooting the r-f system:

a. Figure 29. Transmitting system, complete schematic diagram.

b. Figure 31. R-f system, block diagram.

c. Figure 34. Transmitting-oscillator coupler.

d. Figure 37. Transmission line coupling.

e. Figure 38. T-R box, showing coupling loops.

f. Figure 44. Low-speed rotating joint, phantom view.

g. Figure 45. High-speed rotating joint, phantom view.

h. Figure 47. Antenna, construction details.

i. Figures 79-83. Receiving system, complete schematic diagrams.

j. Figures 285, 286, and 287. R-f components in transmitter, disassembled.

k. Figures 289 through 295. Dehydrator components, disassembled.

242. GENERAL.

a. Most of the troubles encountered in the r-f system are inside r-f lines and connectors. Because the inner and outer conductors must be aligned with micrometer accuracy, repairs should not be attempted on r-f parts in the field unless replacements are impossible to obtain. Trouble can usually be traced to four general faults: a mechanical fault in the rotating joints of the transmission line, burning out of the crystal mixer, lack of air pressure in the transmission line caused by leaky gaskets, and misalignment of the r-f system. Faults less likely to occur include: failure of T-R tube, loss of T-R tube keep-alive voltage, and shorting of the stationary sections of the r-f line.

b. The air pressure in the r-f line, as indicated by the pressure meter on the front panel of the dehydrator should be 3 to 5 pounds. All couplings and rotating joints in the r-f line must be made airtight so that this pressure can be maintained. The couplings and gaskets at the rotating joints and other places in the r-f line are discussed in chapter 3 of this manual. If the weather is dry, the transmission line functions satisfactorily without pressure, provided the line is blown out daily, but the transmission line should not be operated without pressure except in emergency. If the weather is humid or rainy, the line *must* be operated with pressure.

c. The azimuth and elevation low-speed rotating joints and the high-speed rotating joint are shown in figures 43, 44, and 45. A discussion of the mechanical and electrical features of the joints is given in chapter 3 of this manual. The mechanical features of the joints (pars. 47 and 48) are of special interest to the trouble shooter.

d. It is essential that the outer-conductor tip of the transmission line end of the antenna have a solid metal-to-metal contact with the spinner

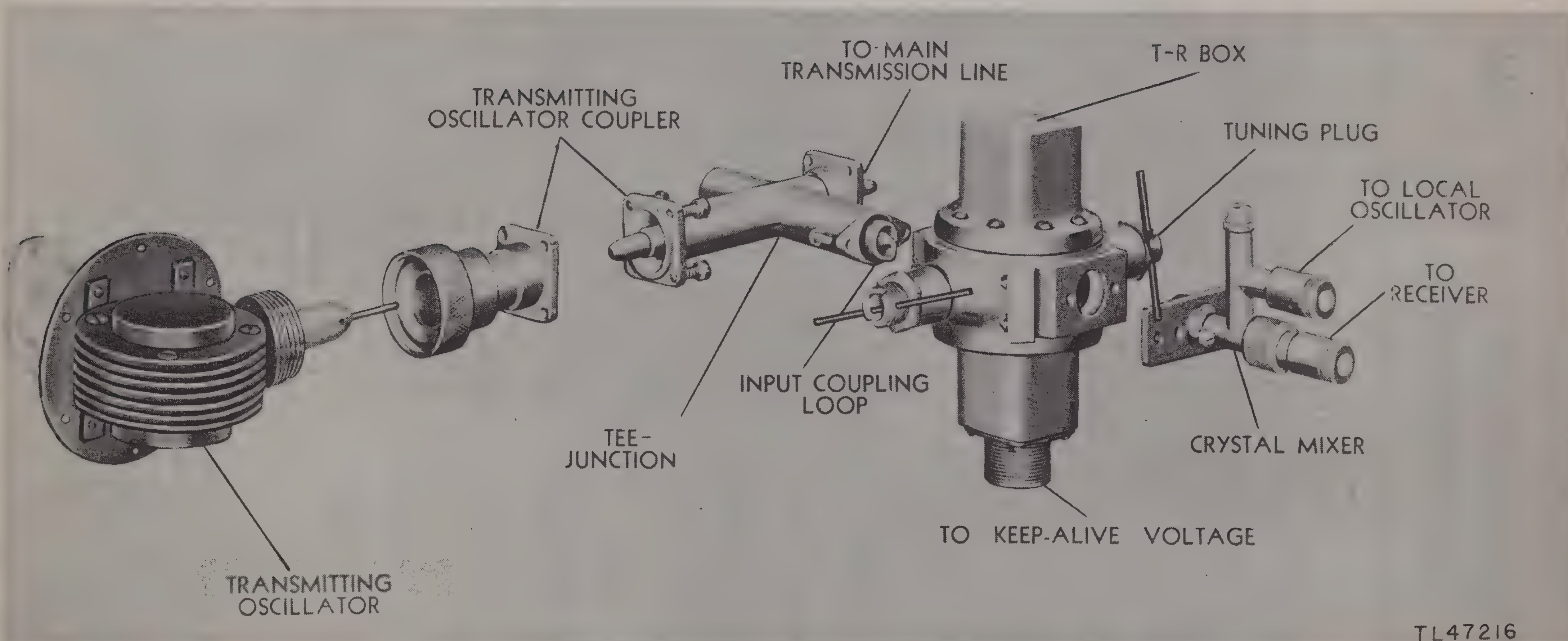


Figure 285. Transmitting oscillator, coupler, T-R box, and crystal mixer, disassembled.

motor rotating line. To test if the antenna is seated properly:

(*1*) Remove the antenna and take off the rubber washer.

(*2*) Replace the antenna (without the washer) and tighten the coupling nut by hand, to the point where binding starts. Mark a place on the spinner motor coupling nut and put a corresponding mark next to it on the edge of the nut.

(*3*) Remove the antenna and replace the washer.

(*4*) Reinstall the antenna and tighten the coupling nut securely. The two pencil marks should line up within a maximum distance of ½ inch. If they do not come within this spacing, the antenna seating is not satisfactory.

(*5*) Remove the antenna and correct the improper seating by slightly reducing the thickness of the washer by trimming with a sharp knife or file.

e. The chart in paragraph 243 below is concerned only with actual faults in the r-f system and not with improper adjustments or improper settings of controls. In symptoms D, E, and F below, the fault could be in the r-f system or in what is generally considered a part of the receiving system. For completeness and clarity in the steps to locate the faults, some of these steps deal with the receiving system. The trouble shooter is not concerned with what system is being checked but only in elimination of the fault. If the transmitting, receiving, and presentation systems are operating normally there is a main pulse on the scopes and the absence of echoes is probably caused by a fault in the r-f system or improper system alignment.

243. R-F SYSTEM, TROUBLE-SHOOTING CHART.

A. SYMPTOM:

High-pitched singing noise coming from the general direction of the r-f line.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. R-f arc at some point inside the transmission line.	1*a*. Locate the origin of the sound by ear and by feeling the r-f line. R-f arcs are most likely to occur at the following places: (*1*) Bullet connector between two sections of line not properly spread (fig. 37). (*2*) Connector to the magnetron output (fig. 34). (*3*) Rotating joints (figs. 44 and 45). (*4*) Broken coupling loops in the T-R box (fig. 38). *b*. When the location of the arc is found, turn off the set and remove the faulty r-f line section. Examine the interior of the r-f line for signs of arcing, such as a sooty deposit or traces of burning. *c*. If the damage is very slight and the fault can be corrected by spreading the tip of a bullet connector or by cleaning, do so; if not, replace the faulty bullet connector or line section (par. 244). If signs of burning are found on the output lead of the magnetron, it is desirable to replace the magnetron (chap. 13).

B. SYMPTOM:

High-pitched squealing sound or noisy rattle coming from the rear end of the high-speed rotating joint (fig. 45).

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Carbon cup bearing which centers the inner conductor bearing pin in the high-speed joint.	1*a*. Replace the rear section of the high-speed joint. *b*. If no replacement section is available, disassemble the rear section of the joint and replace the faulty bearing (par. 245).

C. SYMPTOM:

LINE PRESSURE gauge on dehydrator does not read 3 to 5 pounds air pressure.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Bleeder cap on end of antenna off or loose.	1. Install or tighten the bleeder cap (fig. 47).
2. Dehydrator unit not operating properly.	2*a*. Check to see if the dehydrator compressor motor is heard running. If not, the fault is in the dehydrator control circuits or the motor. See Section II. *b*. If LINE PRESSURE gauge reads more than 5 pounds, the dehydrator cut-out switch is defective. Replace the switch.
3. Leaky gaskets at the transmission line couplings or inside the rotating joints.	3. Inspect gaskets for signs of wear and gaskets and couplings for improper fitting. These checks may necessitate disassembly of the entire transmission line (pars. 244 and 245). In humid or rainy weather any leak in the transmission line should be repaired immediately.

D. SYMPTOM:

CRYSTAL CURRENT meter reading exceeds 0.5 ma.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Local oscillator coupling to crystal mixer is too tight.	1. Reduce coupling by turning mixer coupling screw counterclockwise (par. 259**a**).
2. Defective T-R tube.	2. Replace T-R tube (par. 246).
3. No ionizing voltage on T-R tube.	3*a*. Check for negative 565 volts at jack J209 at the T-R box. If not present, turn off set and remove the cable to the keep-alive electrode at the T-R box. Check the cable for continuity. *b*. Check resistors R216, R217, R218, R219, R220, and R221 in the keyer bias power supply (fig. 29). *c*. Refer to chapter 13, Trouble Shooting in the Transmitting System.
4. Defective CRYSTAL CURRENT meter.	4. Replace meter.

E. SYMPTOM:

CRYSTAL CURRENT meter reading below 0.15 ma.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Misalignment.	1. Retune T-R box, crystal mixer, and local oscillator (par. 259**b**).
2. Defective spring contact nose or base of crystal.	2. Remove crystal (par. 260**b**) and inspect spring contacts inside cavity for breaks or lack of firm contact. Replace the spring contact if it is loose or broken. **CAUTION:** Handle crystals carefully. Keep them shorted with the fingers and touch the hand to the mixer before replacing the crystal to prevent static electricity from discharging through the crystal.
3. Defective crystal.	3. Replace crystal (par. 260**b**). Observe caution note in step 2 above.
4. Defective cabling.	4*a*. Turn off the set and remove the cable from the crystal mixer to the local oscillator. Check cable for continuity. Replace cable if defective. *b*. Remove the cable from the crystal mixer to the preamplifier. Check it for continuity. Replace cable if defective. *c*. Remove the cable connecting J1851 on the preamplifier to J707 on the receiver. Check the cable for continuity of the lead from pin C of P1851 to pin C of P707 and the lead from pin D of P1851 to pin D of P707. Replace cable if defective. Check continuity from pin C to pin D on J707. *d*. Check resistance between pin D of J1851 on the preamplifier and the center conductor of the crystal mixer plug P210. If approximately 150 ohms is not obtained, check the primary of transformer T1852 for continuity, check that capacitor C1853 is not shorted, and check resistors R1851, R1852, and R1860 (fig. 80).
5. Defective CRYSTAL CURRENT meter.	5. Replace meter.

F. SYMPTOM:

Main pulse on range scopes but no echoes or weakened echoes from known fixed targets.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Misalignment.	1. Retune T-R box, crystal mixer, and local oscillator (par. 259).
2. Dirty or corroded T-R tube cavity disks.	2. Remove T-R tube (par. 246) and clean disks if they do not appear defective. Replace T-R tube if defective.
3. T-R box output coupling loop broken.	3. Remove T-R box output coupling loop (par. 246). Repair broken loop if possible, if not replace the loop. Retune the system (par. 259**d**).
4. Burned-out crystal.	4. Replace crystal (par. 260**a**).

244. REPLACEMENT OF R-F LINE SECTION.

Replacement of an r-f line section is a simple mechanical operation. The main requirement is that care be used in handling the sections and no undue strain put on connectors, stubs, coupling loops, and prongs. Because of the difference in physical construction of the several sections of r-f line, detailed instructions cannot be given to cover the replacement of any and all sections. Figure 285 shows some of the line sections and components disassembled. All line connections are made airtight to prevent line pressure leaks. In installing a new section, use only live gaskets in good condition and be sure that the gaskets fit properly. Do not put undue strain on the connector screws or on coupling rings to make airtight connection. This should be accomplished by the gasket. If the replacement section is one using bullet connectors, "feel" that the bullet is spread sufficiently to make a tight fit as the section is moved into position. In replacing a section equipped with coupling loops, loosen the coupling screws and pull the section straight out of the coupling to prevent damage to the loops.

245. DISASSEMBLY OF ROTATING JOINTS.

a. Azimuth and Elevation Low-speed Joints (fig. 44).

(*1*) Remove the screws holding the split flanges to the mounting flange. These screws are in the plate just forward of the drain plug. It may be necessary to rotate the joint slightly to gain access to all the screws.

(*2*) Remove the split flanges and rubber washer.

(*3*) Loosen the line coupling closest to the drain plug on the stationary line section by removing either the transmission line clamp or screws.

(*4*) Pull the joint apart carefully. In this position the joint may be inspected for signs of r-f arcs, cleaned, and the inner conductor and outer conductor bearings cleaned or replaced if necessary.

(*5*) Fine crocus cloth should be used to clean any of the rotating joint parts. All the parts are aligned accurately and strain or careless handling will affect seriously their operation. After cleaning, the sleeve bearing should be coated with a thin film of light machine oil.

(*6*) The joint is reassembled by reversing the disassembly steps above. In assembly, be sure that the slot in the bearing engages the key in the lock washer.

b. High-speed Rotating Joint (fig. 35).

(*1*) Remove the screws from the mounting flange on the rear section of the joint and slide the flange back on the r-f line toward the stub support.

(*2*) Loosen the line coupling closest to the stub support on the stationary section of the joint by removing the coupling screws and pulling the line apart at the coupling. This frees the entire right-angle section of the line to the rear of the joint; so care must be taken not to strain the inner or outer conductors within the joint when this coupling is disconnected.

(3) Pull the joint straight apart.

(4) In this position the joint can be inspected for signs of r-f arcs, cleaned, and the bearing pin of the inner conductor replaced if necessary.

(5) If access to the steel sealing rings, the carbon pressure ring, the bellows seal, or the outer conductor ball bearing is desired, refer to paragraph 354 Disassembly of Reference Generator.

(6) The high-speed joint is reassembled by reversing the disassembly steps above.

246. REPLACEMENT OF T-R TUBE.

Since the T-R tube is inclosed within the T-R box and the tube flanges form part of the T-R box resonant cavity, replacement of the tube involves disassembly of the T-R box.

a. Remove the cable to the keep-alive connection on the bottom end cap of the T-R box.

b. Remove the coupling loop connections to the tee-section and the crystal mixer by loosening the coupling screws at the T-R box (fig. 38) and pulling the connections straight out. Do not damage the coupling loops.

c. Remove the top and bottom end caps of the T-R box by removal of the eight mounting screws holding each end section to the body section (fig. 286).

d. Remove the end cap gaskets from the body section.

e. Disassemble the body section by removing the four screws holding the two sections together (fig. 286). Be careful not to injure the copper flanges of the T-R tube.

f. Remove the T-R tube from the body section of the box.

g. Remove the replacement T-R tube from its container. Wipe off the glass section and the copper flanges gently with a clean cloth free of lint. Do not handle the tube by the glass section or the flanges; handle it only by the keep-alive electrode on the end of the tube.

h. Place the tube in position in the body section of the T-R box. Be sure the tube is properly seated and the flanges are positioned correctly in the cavity of the body section.

i. The T-R box is assembled by reversing the disassembly steps above. Use the same care in protecting the tube, tube flanges, gaskets and coupling loops as was used in disassembly.

j. Figure 287 shows the T-R box completely disassembled.

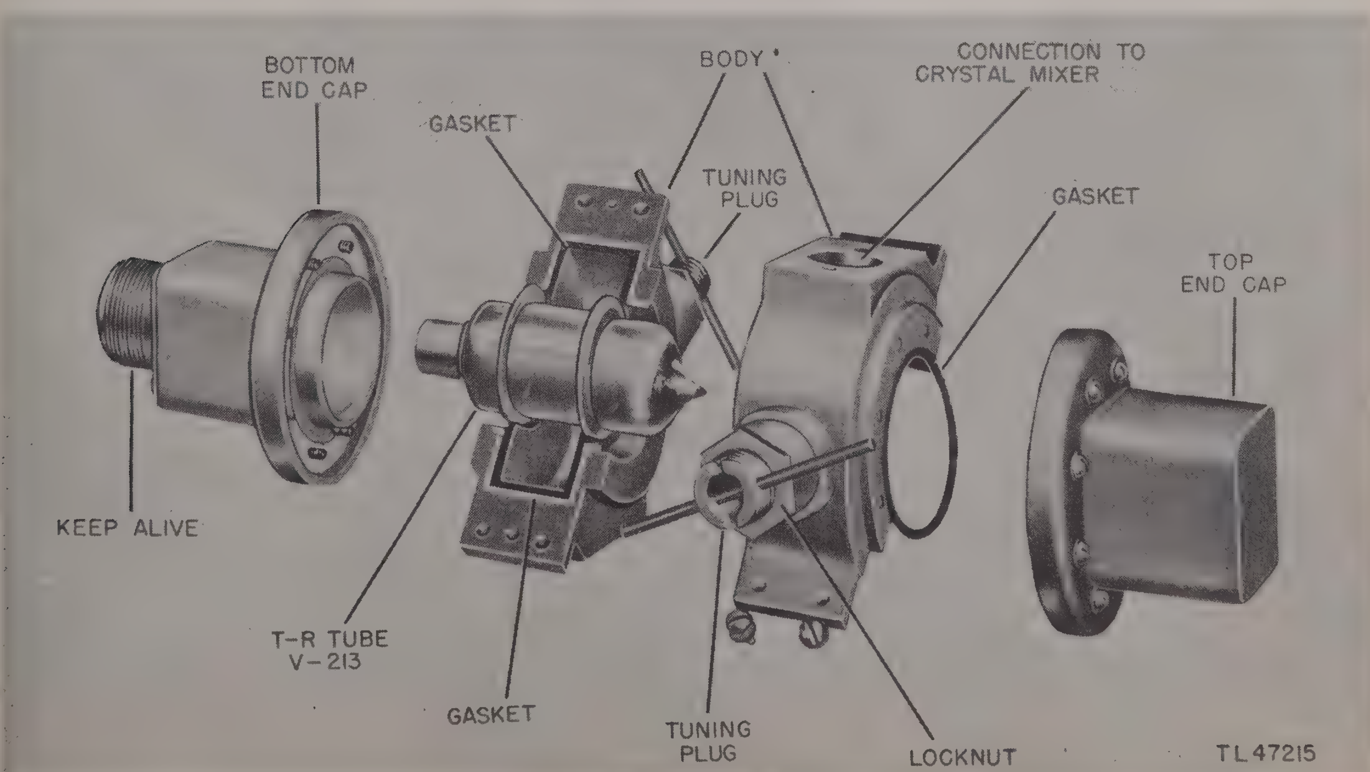


Figure 286. T-R box, partially disassembled.

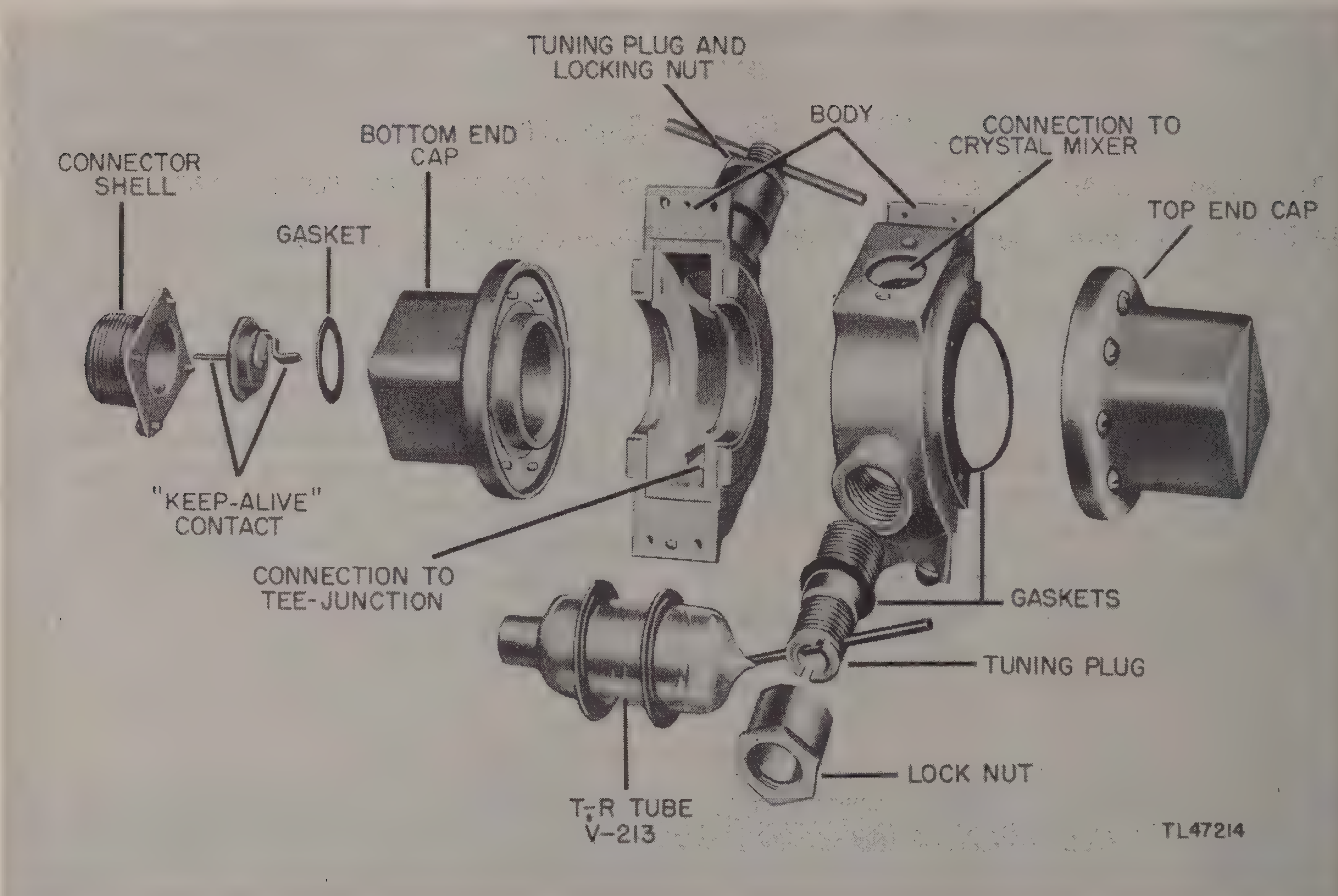


Figure 287. T-R box, completely disassembled.

SECTION II
DEHYDRATOR

247. GENERAL.

The following paragraphs cover the symptoms and servicing of faulty units within the dehydrator. For clarity and completeness, trouble shooting these components is discussed rather than trouble shooting the dehydrator as a whole. Figure 288 shows the location of the various components. Efficient trouble shooting of these components requires an understanding of the operation of the dehydrator (chapter 3, section VII).

248. AIR COMPRESSOR.

The air compressor consists of a diaphragm pump connected directly to a 1/20 horsepower brushless type induction motor. Seldom, if ever should trouble be encountered in the air compressor but should trouble occur the entire unit must be replaced.

a. Indications of Faulty Operation. There are three indications of faulty operation, each of which is discussed below.

(*1*) *Pressure Too High.* If the pressure builds up too high, turn the pressure control

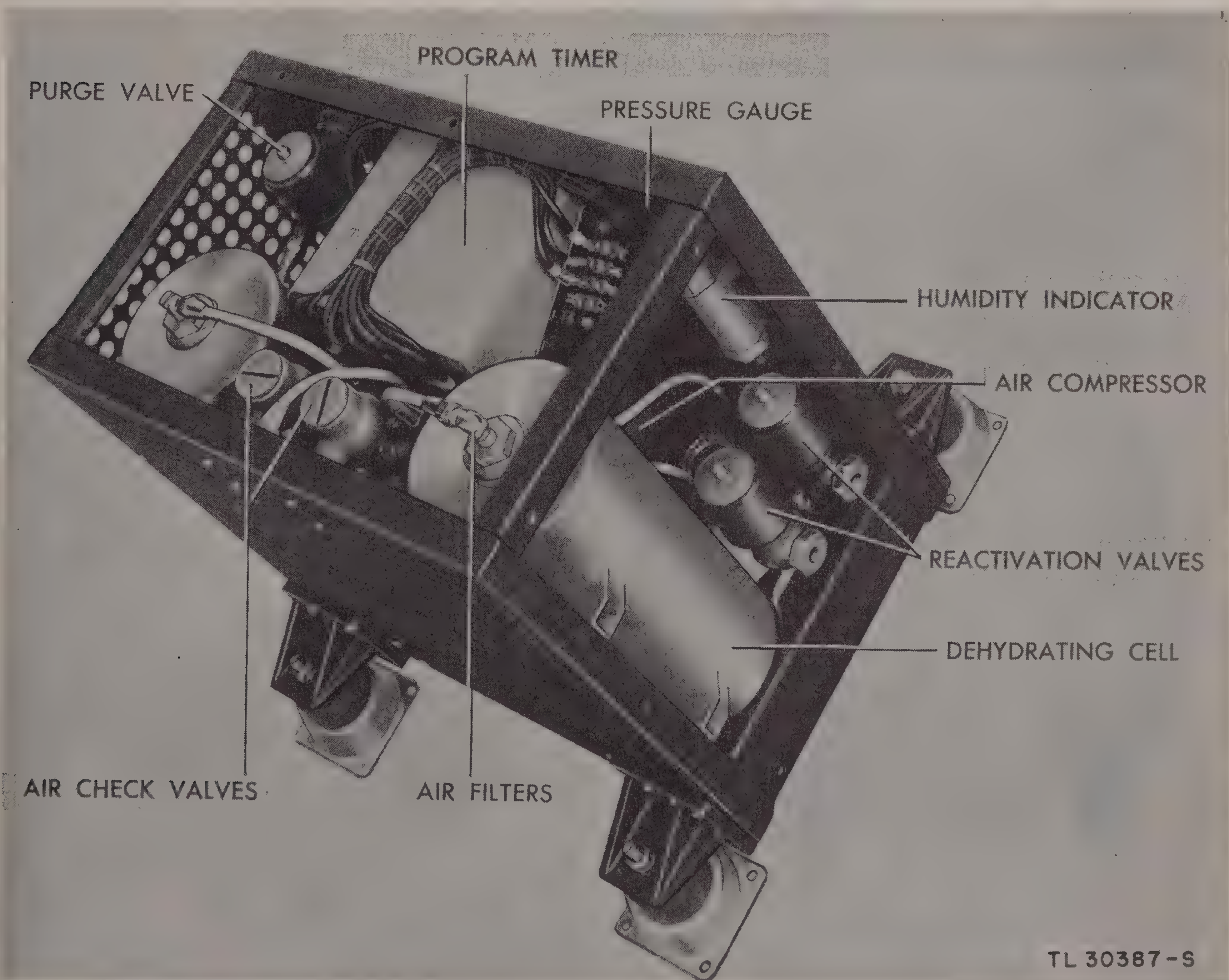


Figure 288. Dehydrator, side and top panels removed.

screw (fig. 289) in the top of the pressure switch counterclockwise. If this does not remedy the trouble, the pressure switch has to be removed and repaired as described in subparagraph **(d)** following.

(*2*) *Compressor Stopped.* If the compressor has stopped running, check the line fuses. One may be burned out. If the fuses are good, turn the slotted screw on the pressure switch clockwise. If the trouble is still not remedied, put a 110-volt test lamp across the yellow and white terminals on the terminal block underneath the cabinet. The test lamp should light; if it does not, the a-c input must be checked. If the bulb lights, the pressure switch, compressor, or wiring to these components has to be repaired or replaced.

(*3*) *Compressor Runs Continuously.* If the compressor runs continuously (not during the purge period), disconnect the flare fittings at the compressor outlet underneath the cabinet and place a finger tightly over the outlet. If the compressor stops very quickly, there must be a leak in the dehydrator or in the transmission line. The leaks can be found by putting soap solution on all joints and valves and then observing the formation of bubbles at the leaky joints. If the compressor does not stop with the finger placed over the outlet, either the valves or the diaphragm or both must be replaced.

b. Removal of Compressor.

(*1*) The program timer and air check valves (fig. 288) must be removed before the compressor can be taken out of the cabinet. To remove the program timer remove the two screws on each side of the timer, and lift the timer out of the cabinet allowing it to hang down over the front panel. The program timer bracket is then removed by first disconnecting the two terminal blocks, one on each side, and removing the screws which hold the bracket to the front panel.

(*2*) The two check valves together with their mounting bracket are removed by discon-

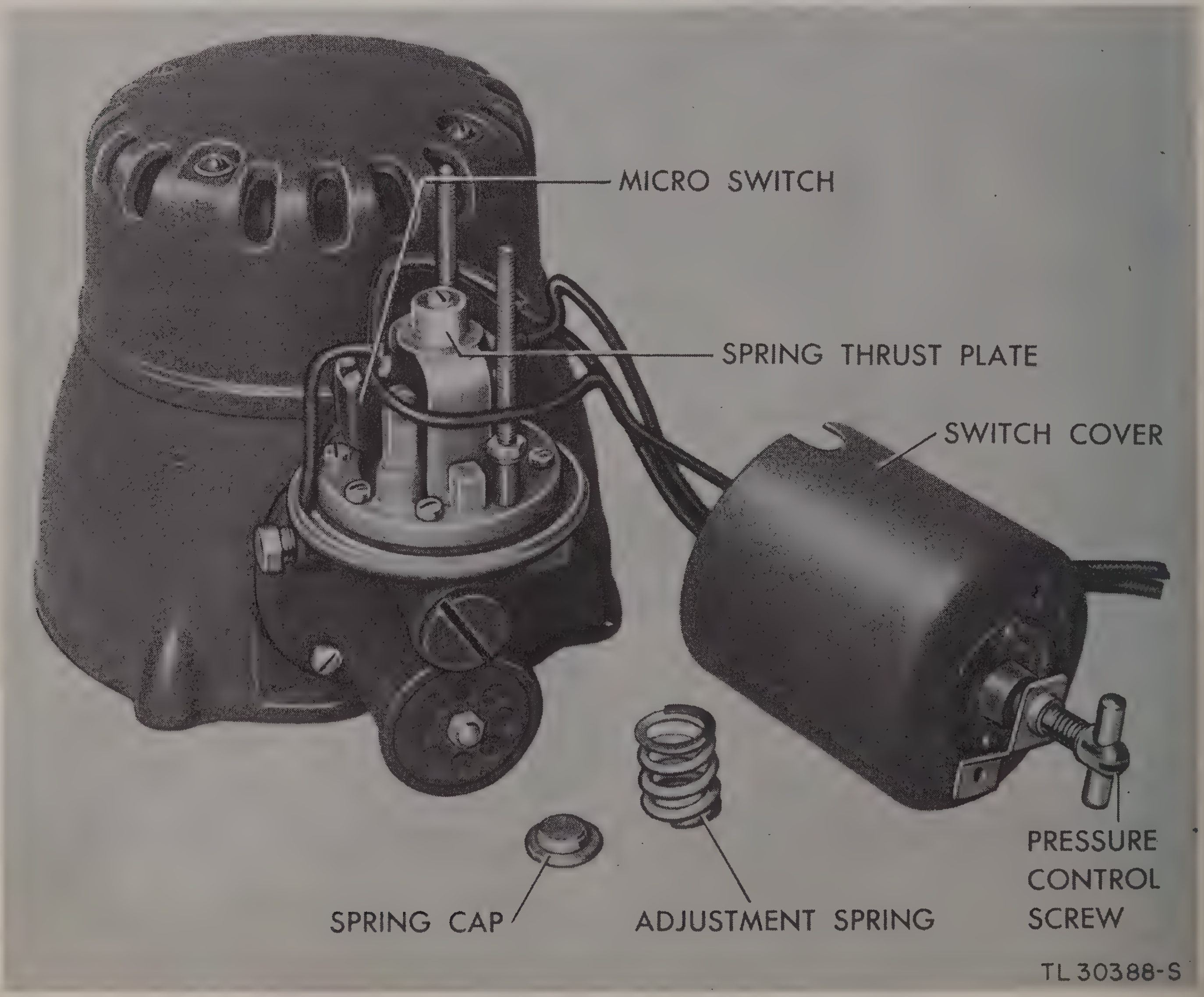


Figure 289. Compressor, pressure switch housing removed.

necting the three flare fittings connected to the valves and then removing the four screws which hold the bracket to the rear panel. The copper tubing must be bent slightly to allow room for the removal of the compressor.

(*3*) To remove the compressor, disconnect the flare fitting under the cabinet. This flare fitting connects the ¼-inch copper tube to the compressor outlet fitting which protrudes through the floor of the cabinet. At the terminal block fastened to the rear panel on the underside of the cabinet, disconnect the three wires (black, yellow, and white) which run from the terminal block to the pressure switch. Remove the four mounting screws which fasten the compressor to the cabinet floor and lift the compressor through the top of the cabinet.

(*4*) The replacement of the compressor program timer and valves is the reverse procedure of the removal.

c. Adjustment of Pressure Switch. The pressure switch is adjusted at the factory so that the compressor maintains a pressure between 4 and 6 pounds per square inch. This pressure is not maintained if the transmission line is leaky. By adjusting the pressure switch it is possible to set the line pressure to any value between 0 and 15 pounds per square inch. If the pressure is set above 8 pounds, the pressure drops to approximately 8 pounds during the purge period and the compressor runs continuously during this period. If the pressure is set below 8 pounds, the compressor runs intermittently during the purge period.

d. Removal of Pressure Switch.

(*1*) When it has been found that the pressure switch is not performing satisfactorily, remove the slotted adjustment screw and the two acorn nuts that hold the switch cover in place. Figure 289 shows the pressure switch disassembled.

(*2*) To remove the microswitch, disconnect the three wires and two mounting screws. The switch is double-pole, single-throw on its output, the input being connected to the power line and the output being connected to the compressor and program timer. When a test lamp is placed across either output terminal and the white line wire, the test lamp should light when the switch is in the closed position but it should not light while the switch is in the open position. If the switch reacts improperly, replace it.

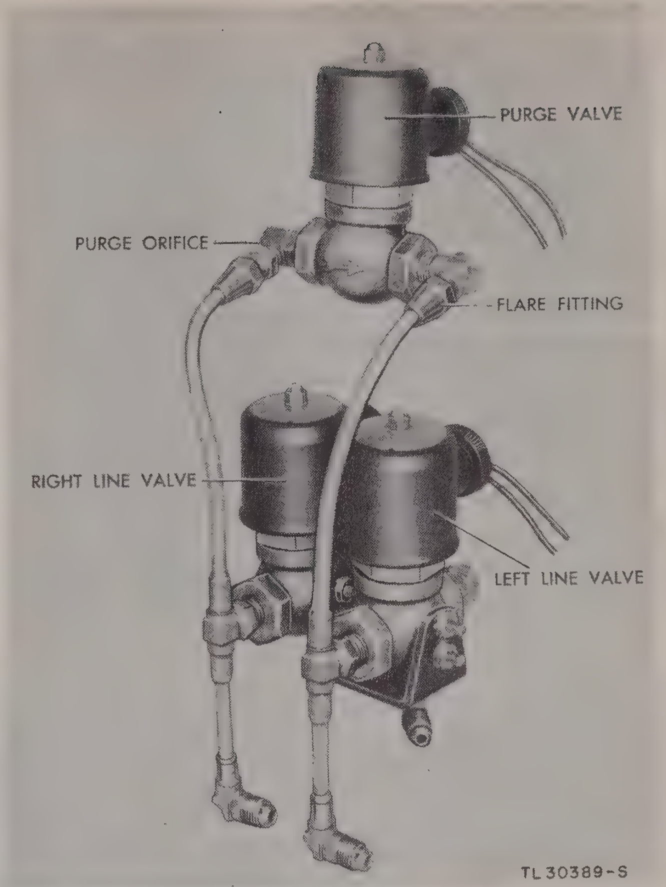


Figure 290. Dehydrator, purge and line valve assembly removed.

(*3*) The spring cap fits onto the end of the adjustment spring and the free end of the spring is placed over the spring thrust plate. The switch cover is placed over the two studs and the acorn nuts are placed and tightened. It may be necessary to readjust the throw of the microswitch by turning the little screw on the top end of the switch yoke. Turn clockwise to widen the spacing and turn counterclockwise to narrow the spacing. The switch housing has to be replaced after each adjustment.

249. VALVES.

The left and right line valves, purge valve, and purge orifice form a complete unit and must be removed as a group when it becomes necessary to service any one of them. Figure 290 shows the valves removed from the cabinet.

a. Faulty Line Valves.

(*1*) The left and right line valves are normally closed solenoid valves. If the right line valve fails to open, when the green contact on the program timer is closed, the compressor pumps up to its cut-out pressure and shuts off. Therefore, the line pressure does not build up,

and dry air is not delivered. This condition is also true should the left line valve not open when the blue contact in the program timer is closed.

(*2*) A check to see whether a line valve is open can be made by loosening the flare fitting which connects the valve to the finned tube. If the compressor is running, air should escape. Another indication of an improperly operating line valve is that the humidity indicator turns pink during a cooling period because the air passing through the hot silica gel will not lose any of its moisture.

b. Faulty Purge Valve. The purge valve is the same type valve as the line valves. If it fails to close when the yellow-black contact opens, then the humidity indicator turns pink during either of the cooling periods. If the valve sticks open, the compressor runs continuously during the reactivation period. If the valve stays closed all of the time, the system is not properly purged and the humidity indicator may turn color for a short period of time during the first part of a cycle.

c. Faulty Purge Orifice.

(*1*) The purge orifice provides a restriction in the purge line so that a pressure of about 8 pounds is maintained in the active dehydrating cell while the other cell is being purged of steam and moisture. If this orifice becomes plugged, the dehydrator cuts out just the same as if the purge valve were closed all of the time.

(*2*) If the little cleaning wire in the orifice gets out of place, the dehydrator will not main-

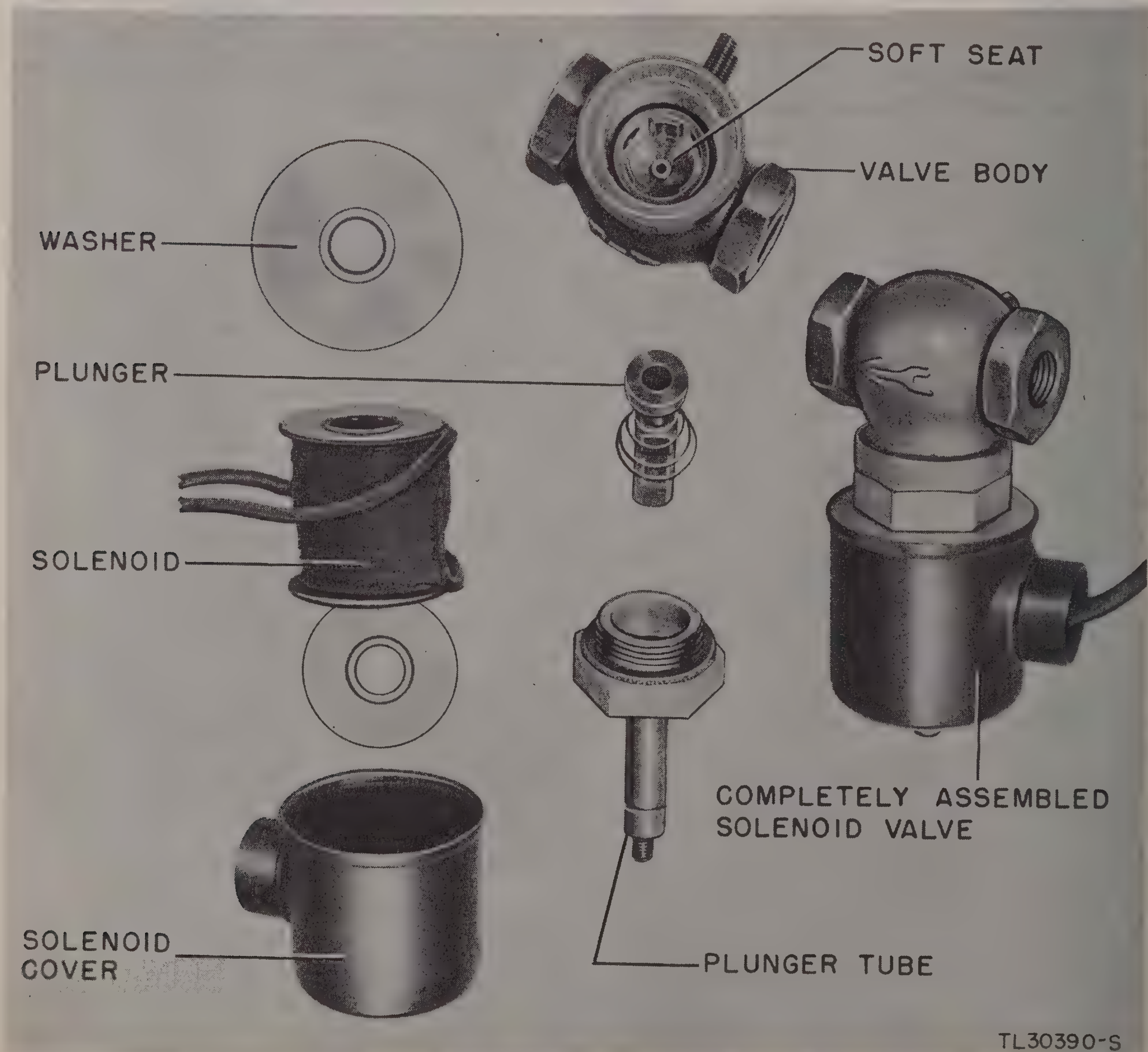


Figure 291. Solenoid valve, disassembled.

tain the 8 pounds pressure during the purge period. This orifice may be examined by removing the flare fitting nut on the side of the purge valve. By using two wrenches the orifice can be replaced without removing the valve.

d. Disassembly of Valve.

(*1*) *Burned-out Coil.* If a coil is burned out, it can be removed by removing the nut on the top of the coil cover and pulling the cover and the coil from its place. When removing the coil, care must be taken not to damage the tube protruding up through the center of the coil. When replacing a coil, make good solder joints at the terminal block and observe the proper color code at the wires. Figure 291 shows a valve completely disassembled. All the solenoid valves in the dehydrator are the same.

(*2*) *Leaky Valve.* If a valve is found to be leaking badly, it must be replaced completely or the soft seat should be replaced with a new one. After the solenoid is removed from its housing, unscrew the plunger tube. The soft seat is now exposed and can be removed. The plunger can be removed easily and inspected for improper operation. Should the tension of the plunger spring need adjustment replace the entire spring. The reassembly of the valve is the exact reverse of the disassembly.

250. DEHYDRATING CELLS.

The dehydrating cells are cylindrical chambers filled with silica gel and equipped with heaters for driving moisture out of the used gel. To remove the cyclinder, simply disconnect the top and bottom flare fittings, remove the wires from the heater and thermoswitch and finally remove the four mounting screws holding the cylinder to the back panel brackets. The position of the dehydrating cells is shown in figure 288. Figure 292 shows a dismounted dehydrator cell with parts identified.

a. Heaters. These are built-in heaters each rated at 500 watts 110 volts. If the heater is faulty, the entire dehydrating cell must be replaced. During the reactivation period the heater should heat the cylinder to about 400 degrees F. If the cylinder does not become hot, put a 110-volt lamp across the heater terminals. If the bulb lights properly, then the heater is at fault and the entire cylinder must be replaced. If the bulb does not light, the thermoswitch is not operating satisfactorily and the heater circuit is broken.

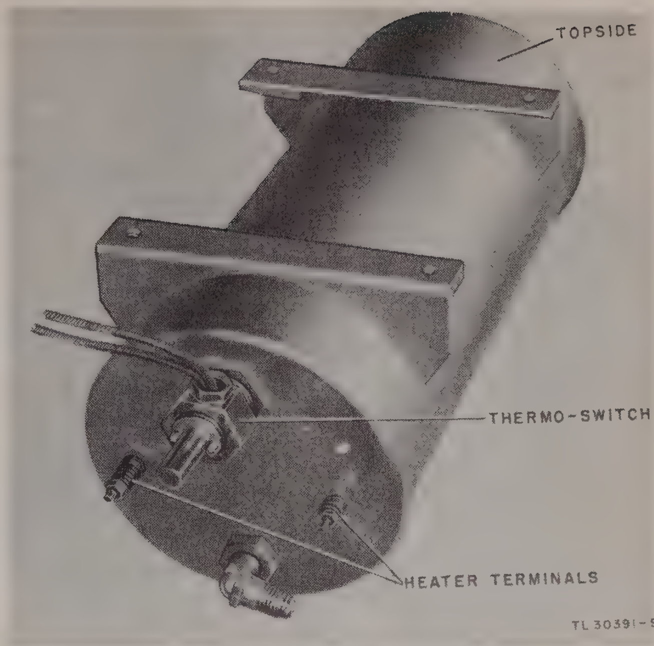


Figure 292. Dehydrating cell, parts identified.

b. Thermoswitches. The thermoswitches allow the temperature in the cylinders to rise to about 400 degrees. If the temperature does not rise high enough, turn the adjustment screw on top of the switch clockwise. If the temperature is too high, turn the adjustment screw counterclockwise. A test lamp may be used to test the thermoswitch for continuity. If a thermoswitch is found to be faulty, it must be replaced. To remove a switch, simply disconnect the wires and turn the switch out of the tapped hole in the dehydrating cell. When replacing the new switch, put gasket cement on the threads of the switch, turn it in tightly and then connect the wires.

c. Air Filters. The air filters (fig. 288) are glass-cloth dust filters capable of withstanding the high temperature in the dehydrating cells. Should the dust pads become filled with dust to the extent of stopping the flow of air through the filter, they must be replaced. This is done by removing the hex. cap and putting in new pads. The coarse pad is placed on the bottom next to the bottom screen. When reassembling, a new copper-asbestos gasket should be used and gasket cement should be applied to the gasket and threads.

d. Air Check Valves. The air check valves (fig. 288) are made of neoprene and can be replaced easily. If either valve develops a leak, the compressor runs more frequently during the

reactivation period. To replace a valve, remove the cap on top, remove the valve retainer bushing, and lift out the valve. When installing a new valve, put the new valve on the center of the valve seat, replace the bushing and tighten securely. Put gasket cement on the lead gasket and replace the top cap.

251. REACTIVATION VALVES.

The reactivation valves are solenoid valves which are exactly the same type as the line and purge valves. The repair and disassembly is the same as described in subparagraph 249**d**.

a. If a reactivation valve remains closed during the time that it should be open, steam escapes into the transmission line causing the humidity indicator to turn pink. When the red contact in the program timer is closed, the right reactivation valve must be open. When the blue-yellow contact on the program timer is closed, the left reactivation valve must be open.

b. Should a reactivation valve stick during the time it should be open, line pressure will not build up properly. For example: if the right reactivation valve remains open, while the right line valve is opened supplying air to the right dehydrating cell, the air escapes through the reactivation valve and the line pressure will not build up. The left and right reactivation valves should be removed as a unit if either has to be serviced.

252. HUMIDITY INDICATOR.

The humidity indicator consists of a transparent plastic tube filled with silica gel.

a. Humidity Characteristics. When the little particles in the indicator are deep blue in color the relative humidity of the air is something less than 10 per cent and when the gel is blue-gray in color the relative humidity is about 20 percent. For values of relative humidity above 30 percent the indicator turns pink, reaching a clear pink at about 60 percent relative humidity. A pink color is an indication of an improperly operating dehydrator. Except in the case of continuous operation of the entire unit with a surrounding atmosphere of 100 degrees F and a relative humidity of 100 percent, the humidity indicator should remain a deep blue color. In this extreme condition, the indicator may turn to a blue-gray color during the last hour of the cooling period; however, the color should change to a deep blue immediately after the half cycle has been completed.

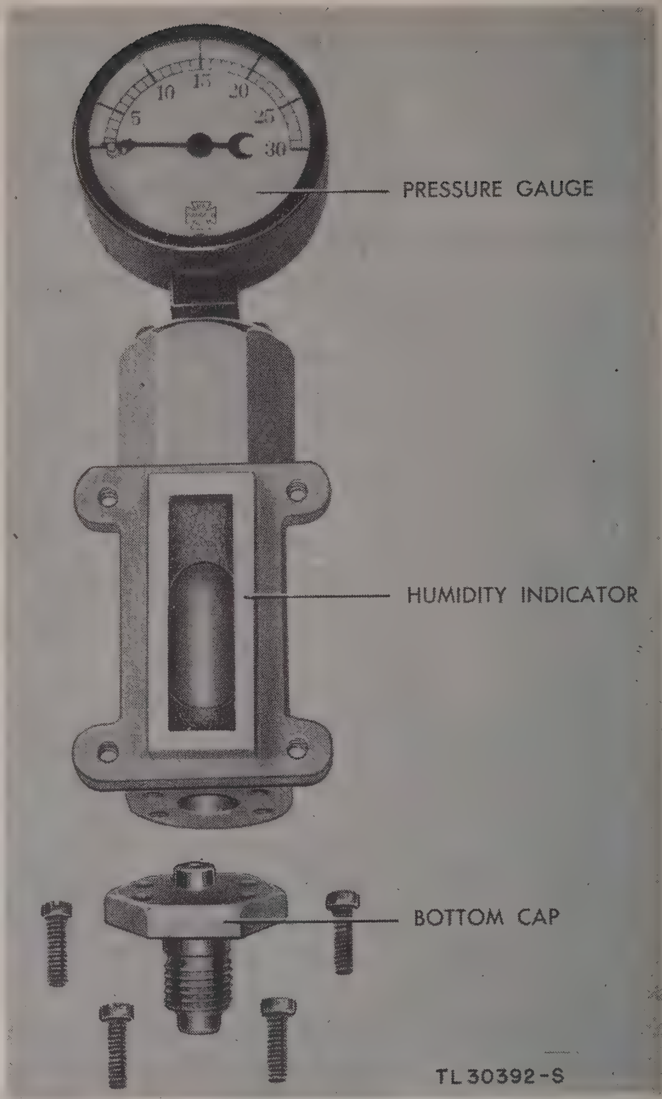


Figure 293. Humidity indicator removed for filling.

b. Refilling the Humidity Indicator.

(*1*) After several months of normal operation, the indicator may turn to a brownish green color, in which case it should be refilled with new indicating gel. To refill the humidity indicator it is necessary to remove the entire unit from the panel. Figure 293 shows the entire humidity indicator removed for refilling. To remove the indicator disconnect the two flare fittings and nuts located at the lower end and at the top back side. Remove the four panel mounting screws and lift out the indicator with the pressure gauge attached. Remove the four screws holding the bottom cap in place. Pour out the indicating gel and remove the plastic tube. Make sure that all the loose particles have been removed from the body before reassembling.

(*2*) Replace the plastic tube and fill it with blue indicating gel up to 1/16 inch from the open

end. Replace the bottom end cap carefully and tighten it securely with the four screws. These screws must be tightened evenly. Mount the indicator on the front panel and connect the flare fittings.

253. PRESSURE GAUGE.

If the pressure gauge is damaged, the complete humidity indicator must be removed from the dehydrator as described in the above paragraph. The pressure gauge can be removed by unscrewing it from the top of the indicator by using two wrenches. The threads on the new gauge should be coated with gasket cement. The new gauge must be screwed into the indicator to the same depth as the old gauge. After the new gauge has been coupled to the indicator, the complete indicator assembly should be remounted on the dehydrator panel. Make certain that the flare fittings are tight so that pressure-tight joints are assured.

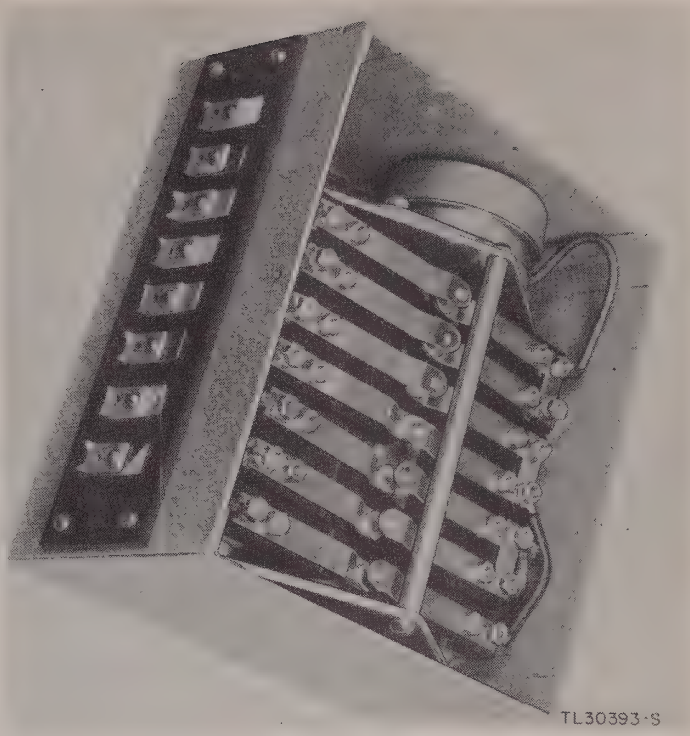


Figure 294. Program timer.

254. PROGRAM TIMER.

The program timer consists of a series of switches opened and closed at desired times by cams attached to a rotating shaft. If the program timer is not operating satisfactorily, it should be replaced by a new one. When a new timer is placed in the dehydrator and if time permits, disconnect the dehydrator from the transmission line and allow it to run continuously for 12 hours in order to obtain the correct cycle. If time does not permit, examine the position of the cams on the old timer. Loosen the cam shaft gear setscrews of the new timer and rotate the cam shaft so that the cams are in approximately the same position as the old timer. Tighten the setscrews and install the new timer.

CHAPTER 15
TROUBLE SHOOTING IN THE RECEIVING SYSTEM

WARNING: *Voltages sufficiently high to cause death exist in the receiver system. Care must be taken in measuring the local oscillator power supply voltages. Always short out the power supply capacitors before taking resistance measurements on the set.*

255. REFERENCE DATA.

The following reference data will assist maintenance personnel in trouble shooting, adjusting, and repairing the receiver system.

a. Receiver.

Figure 81. Schematic diagram.
Figure 69. Top view.
Figure 300. Bottom view, parts identified.
Figure 301. Voltage and resistance chart.

b. Preamplifier.

Figure 80. Schematic diagram.
Figure 59. Top view.
Figure 295. Bottom view, parts identified.
Figure 304. Voltage and resistance chart.

c. Remote Video Amplifier.

Figure 82. Schematic diagram.
Figure 76. Top view.
Figure 296. Bottom view, parts identified.
Figure 297. Voltage and resistance chart.

d. Local Oscillator and Local Oscillator Power Supply.

Figure 79. Schematic diagram.
Figure 59. Top view.
Figure 298. Bottom view, parts identified.
Figure 302. Voltage and resistance chart.

e. Receiver Power Supply.

Figure 83. Schematic.
Figure 78. Top view.
Figure 299. Bottom view, parts identified.
Figure 303. Voltage and resistance chart.

f. Receiver System.

Figure 56. Complete block diagram.

g. Crystal Mixer.

Figures 63 and 64. Construction.

256. CONTROL SETTINGS.

Before starting trouble-shooting operations, the controls affecting the operation of the set should be adjusted so that their position approximates that of normal operation. These preliminary adjustments, while not accurate, are necessary before any attempt is made to align or repair the set. There are four controls in this system that should be preset.

a. AGC-OFF Switch. The AGC-OFF switch should be turned to the OFF position disconnecting the automatic bias from the 2d and 3d i-f stages. This connects the manual gain control in the circuit. The maximum gain is dependent on the setting of this manual control.

b. Volume Control. The VOLUME control on the front panel should be turned fully clockwise, decreasing the bias on the 2d and 3d i-f stages to zero and increasing the gain to maximum. This is not the normal operating position

of the control but during the trouble-shooting operation maximum sensitivity to echoes, rather than appearance of the echoes on the scopes, is preferred.

c. Sensitivity Control. The SENSITIVITY control, a screwdriver adjustment, should be turned clockwise for the maximum gain of the range channel.

d. AGC ADJ Control. The AGC ADJ control should be set so that the voltage at pin 4 of tube V701 is at zero volts when the VOLUME control is maximum clockwise, with the AGC switch in the OFF position.

257. GENERAL TROUBLE-SHOOTING PROCEDURE.

Faults that exist in the receiver system may be isolated and traced by observing the visual indications presented by the components of the system, and by systematically checking the voltages and resistances at key points. Thus, the basis of the trouble-shooting procedure can be developed by the use of the symptoms of abnormal or normal operation of the system. With the interpretation of these indications and symptoms, the system is effectively subdivided into separate sections, narrowing and localizing the faults. Every attempt should be made to use the visual indications in isolating the trouble before any component is removed for testing. The following checks and tests of each component aid the repairman in analyzing and locating the troubles.

a. Local Oscillator and Crystal Mixer. These two components are the heart of the receiver system and if either one is faulty the target presentation and automatic tracking is affected. Even slight misalignment or too loose coupling interferes with the proper operation of the set (par. 259).

(*1*) The easiest and quickest check for proper operation is the reading on the CRYSTAL CURRENT meter. A normal reading (0.15 to 0.5 ma) indicates that these parts are functioning properly and that if the set is inoperative the trouble lies between the mixer and the range scopes. Too high a reading indicates that the klystron coupling of the mixer is too tight, or the T-R box is out of tune, while zero crystal current indicates that:

(*a*) The crystal is burned out. The defective crystal should be replaced with a good one in accordance with the instructions in paragraph 260**b**.

(*b*) The coupling of the klystron to the mixer is completely out of alignment. The coupling to the crystal mixer can be checked easily by turning the coupling knob, watching the CRYSTAL METER for an increase or decrease of crystal current.

(*c*) The klystron is not oscillating. Check the settings of the klystron controls, the output voltages of the klystron power supply, and the beam current developed in the tube, measured between jacks J1805 and J1806.

(*2*) The control marked COMP VOLTS adjusts the voltage relations of the power supply so that the klystron maintains oscillations at a constant frequency during line surges. If the echoes on the scopes fade out with line surges, proper setting of this control may eliminate the trouble.

(*3*) The REFLECTOR VOLTS control is the critical adjustment for starting the klystron into oscillation. Before starting with the trouble-shooting procedure, adjustment of this control should be made to check for a faulty setting.

(*4*) The GRID VOLTS control should be set to maintain a beam current output of approximately 20 ma between jacks J1805 and J1806.

b. Preamplifier. The preamplifier circuit is very sensitive and exact operation of these two stages is necessary to present the proper data on the scopes. Any noise generated or picked up in these stages is amplified by the succeeding stages and may seriously interfere with the target echoes displayed on the scope. With an abnormal amount of grass and interference on the scope, the tubes, wiring, and shielding of these stages should be checked. When trouble shooting the component, the voltages measured at the pins of the tubes should be within 15 percent of the readings on the voltage charts. Any variation greater than 15 percent affects the target echo presentation. One indication that the preamplifier is working properly is normal grass on the scopes. With a defective preamplifier stage the grass level is very low or absent.

c. Receiver. The receiver and the remote video amplifier can be divided into six sections, which although dependent on one another may be analyzed separately when trouble shooting.

(*1*) *I-f Stages* (*3d, 4th, 5th*). These stages are common to both the servo and range channels and trouble in any of these three tubes V701, V702, and V703 causes the automatic tracking unit to become inoperative or erratic and the range scope target echoes to be distorted or lost. If either the range channel or the servo channel has a normal output and the other is not operating properly these common stages may be eliminated and the faulty channel inspected for trouble. If both channels are inoperative, no grass on either scope, and the crystal current is normal the fault probably exists in these common stages. Replacement of tubes and voltage and resistance checks should be made.

(*2*) *Servo Channel.* If target echoes are being received on the range scopes and the automatic tracking unit is not working, or it is working erratically, the trouble most likely is in the servo channel. However, even if these stages are normal, their proper operation depends on the gating signal from either the range unit or the automatic range tracking unit, and the bias voltage on the 6th i-f amplifier V704. Connect the test scope between pin 6 of tube V704 and ground and check for a positive 80- to 100-volt pulse. If the proper trigger gate is present, and the channel is still defective, voltage and resistance measurements should be made in each stage, and the tubes replaced, if necessary.

(*3*) *Range Channel.* The range channel feeds the range and PPI scopes through the remote video amplifier. Faults isolated to this stage can be localized by taking waveforms at pin 5 of tube V1102, the 1st video amplifier. With the indications at this central point, the trouble is further narrowed to the preceding or following stages. Replacement of tubes and voltage and resistance measurements of the faulty section should be made.

(*4*) *Voltage Regulator.* The output of the voltage regulator tubes V708 and V709 supply the plate and screen potentials of the i-f stages. Too high a plate supply would change the operating characteristics of the i-f stages, causing saturation of normal echo signals. With too low a supply, weak signals would not be amplified sufficiently to appear on the range scopes or to operate the automatic tracking unit. A check on the appearance of known fixed targets and voltage measurements at pin 6 of tube V709 detects this fault.

(*5*) *Narrow Gate Circuit.* The operation of the narrow gate circuit affects only the servo channel. Checking the waveforms at pin 5 of tube V710 and pin 8 of tube V712 isolates the stages. Replacement of tubes and voltage and resistance checks should be made on the circuit. Target echoes appear on the range scope even if these stages are faulty.

(*6*) *AGC Circuit.* The AGC circuit controls the bias on the 2d and 3d i-f stages. If the sensitivity to target echoes is very low or automatic tracking is erratic, voltage measurements should be made at pin 4 of tube V701. A faulty bias voltage could either cut off the i-f stages or allow only very strong echo signals to appear on the scope. Check the action of relay K701, the VOLUME control R738, and the AGC ADJ potentiometer R743. Rotation of these controls should increase and decrease the voltage at pin 4 of tube V701 (par. 256).

d. Power Supplies. The receiving system uses three power supplies to provide the proper operating potentials on the various components.

(*1*) *Rectifier, 300-volt.* This power supply provides the plate and screen voltages directly for the video stages of both channels, the narrow gate circuit, the voltage regulators, and the 7th i-f stage of the range channel. Indirectly through the voltage regulator circuit, it provides the plate and screen voltages for the remaining i-f stages and the AGC circuit. The output is measured between pin H of jacks J1001 and J1002 and ground. If there is no output, or if it is too low, the receiver is inoperative. The pilot light on the chassis indicates whether or not power is applied to the circuit. Tubes V1001 and V1002 should be replaced as the first step in trouble shooting; then voltage and resistance checks should be made in the rectifier circuit.

(*2*) *Rectifier, 105-volt.* This power supply provides the bias for the AGC circuit, the 6th i-f servo stage, and the voltage regulator. A faulty supply interferes with the operation of the automatic tracking unit and may cause the target echoes to become distorted through the action of the AVC circuit. The output is measured between pin B of jacks J1001 and J1002 and ground. With an output appreciably higher than the normal -105-volt value, the voltage regulator tube V1004 should be replaced.

With no voltage output, tube V1003 should be replaced and voltage and resistance measurements taken in the rectifier circuit. Switch S1001 and fuses F1001 and F1002 should be checked also if both power supplies are dead.

(3) *Local Oscillator Power Supply.* The local oscillator uses two half-wave rectifiers, tubes V1801 and V1802, for the operating voltages. As the voltages necessary to keep the klystron in oscillation are critical, proper regulation is important in this supply. The settings of the REFLECTOR VOLTS control and the GRID VOLTS control are important in maintaining oscillations. Voltage readings taken at the cap, the grid (pin 5), and the cathode (pin 8) should be nearly the value indicated on the voltage charts.

Tube V1801 controls the grid and cathode circuit of the klystron, and this circuit should be checked if the voltage at these points is abnormal. The filter network should be checked thoroughly if the approximate voltages are present but the tube operation is erratic. Tube V1802 and the regulator tubes V1804, V1805, V1806, and V1807 control the voltage applied to the reflector plate and this circuit need be checked only if the reflector voltage is not normal. Fuses F1801 and F1802 and switches S1801 (FILAMENT) and S1802 (PLATE) control the a-c voltage applied to the circuit.

CAUTION: High voltages are present in this power supply.

258. RECEIVER SYSTEM, TROUBLE-SHOOTING CHART.

A. SYMPTOMS:
1. No signals or grass on scope screens.
2. No output to automatic tracking unit.
3. Crystal current normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Coaxial cables between components.	1. Check the coupling and cables between the mixer and preamplifier, and between the preamplifier and receiver (fig. 57).
2. Receiver power supply.	2*a*. Note if the pilot light on the receiver chassis is lit. (If it is not lit refer to steps *e*, *f*, and *g* below.)
	b. Measure the voltage at jacks J1002 and J708 between pin H, pin B, and ground. The voltage should be +300 and –105 respectively.
	c. Replace tubes V1001 and V1002 or replace tubes V1003 and V1004 depending on which voltage is abnormal.
	d. Take voltage and resistance measurements of the circuits.
	e. Check fuses F1001 and F1002.
	f. Check the voltage at jack J1003 to be 115v ac.
	g. Check switch S1001.
3. Voltage regulator circuit.	3*a*. Measure the voltage at pin G of jack J707 (fig. 300).
	b. Replace tubes V708 and V709 if voltage is not 120v.
	c. Take voltage and resistance measurements of the regulator circuit.

4. 1st and 2d i-f stages.	4*a*. Replace i-f tubes V1851 and V1852. *b*. Take voltage and resistance measurements of these two stages (fig. 304).
5. One or more tubes in the i-f section of the receiver.	5*a*. Replace i-f tubes V701, V702, and V703. *b*. Take voltage and resistance measurements of these stages (fig. 301).

B. SYMPTOMS: 1. No signal on range or PPI scope screens.
2. Output to automatic tracking unit is normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. 6th or 7th i-f stages (range channel).	1*a*. Connect the test oscilloscope between the plate of the tube V1102 (pin 5) and ground. Lack of echoes or grass indicates trouble between the 5th i-f and 2d detector. (If normal signals appear, refer to steps 3 and 4 below.) *b*. Replace tubes V711 and V1101. *c*. Take voltage and resistance measurements of the circuits (fig. 301).
2. Coaxial cable.	2. Check the coupling and cable between the receiver and remote video amplifier (fig. 57).
3. Video stages.	3*a*. Replace tubes V1103 and V1104. *b*. Take voltage and resistance measurements of the circuits (fig. 297).
4. Coaxial cable.	4. Check the coupling and cable between the remote video amplifier and the scopes.

C. SYMPTOMS: 1. Automatic tracking unit inoperative, or erratic.
2. Range and PPI scopes normal.
3. Normal N^2 gate from automatic range tracking unit.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. No narrow gate applied to receiver servo channel from range unit.	1*a*. Check the narrow gate input at pin 5 of tube V710 with test oscilloscope to be about 80 volts. *b*. Check the input at pin 6 of tube V704. *c*. If no input to pin 6 of tube V704, replace tubes V710, V712, V714 one at a time. *d*. Make a voltage resistance check of these stages (fig. 301).
2. Switch S702.	2. Check switch S702 for proper contact (fig. 300).
3. Negative bias on 6th i-f stage.	3. Check the negative voltage at pin 6 of tube V704. If abnormal, check steps *c* and *d*, of symptom A, procedure 2.
4. Tubes in servo channel.	4*a*. Check for video at pin 4 of tube V707; if no signal replace tubes V704, V705, and V706. *b*. Take voltage and resistance measurements of the servo stages (fig. 301).
5. Defective cable.	5. Check the cable from the receiver to the automatic tracking unit (fig. 57).

D. SYMPTOMS: 1. Crystal current normal.
2. Erratic tracking on automatic.
3. Alternate weak and strong target echoes.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. AGC circuit.	1*a*. Replace tube V713. *b*. Check relay K701 by operating the AGC switch. *c*. Turn the AGC switch to OFF. Use the VOLUME control to try to stabilize the echoes.
2. Voltage regulator circuit.	2*a*. Check voltage at pin 6 tube V709 to be 120v. *b*. Replace tubes V708 and V709. *c*. Make a voltage resistance check of these two stages (fig. 301).
3. Power supply filter network.	3. Take voltages and resistance measurements of the circuits.
4. Wiring or tube in common i-f stages.	4. Inspect the circuit for loose connections. Replace tubes in i-f channel.

E. SYMPTOMS: 1. Zero crystal current.
2. Grass but no signals.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Crystal mixer.	1*a*. Retune crystal mixer (par. 259**c**). *b*. Remove crystal and inspect condition of spring and contacts; replace if necessary (figs. 63 and 64). *c*. Replace crystal. (If new crystals burn out immediately, see step 4 below.) **CAUTION:** Handle crystals carefully, keeping them shorted with the fingers, and be sure to touch the mixer before releasing the short on the crystal. This is to prevent static electricity from discharging through the crystal.
2. Local oscillator power supply.	2*a*. Check input voltage on jack J1801 and fuses F1801 and F1802. *b*. Check voltages at the cap and at the pins 2, 5, 7, and 8 of tube V1803. **CAUTION:** Some of these voltages may be as high as 960v dc. *c*. Check REFLECTOR VOLTS, GRID VOLTS and COMP VOLTS controls. *d*. Replace tubes V1801 and V1802. *e*. Check voltage regulator tubes V1804, V1805, V1806, and V1807 *f*. Take voltage and resistance measurements of the circuit (fig. 302).
3. Local oscillator tube.	3. Replace tube V1803, refer to paragraph 260**a**.
4. T-R box.	4*a*. Retune T-R box, paragraph 259. *b*. Check the keep-alive voltage.

F. SYMPTOM: Noticeably weakened echoes from known fixed targets on scope screens.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. System out of line.	1. Check tuning of local oscillator; refer to tune-up procedure, paragraph 259.
2. Power supply.	2. Refer to procedures of symptom A; 2*b*, *c*, *d*, and *e;* and 3.
3. Tubes aging.	3. Replace tubes in receiver channel.

G. SYMPTOMS: 1. Grass but no signals on scope screens.
2. Crystal current normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Preamplifier coaxial cable.	1. Check the coupling and cable between the mixer and the preamplifier (fig. 57).
2. R-f system.	2. Check the r-f system ahead of the mixer.

H. SYMPTOMS: 1. High crystal current.
2. Normal echoes on scope screen.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Local oscillator coupling.	1. Reduce the local oscillator coupling to the crystal mixer by turning mixer coupling screw counterclockwise.

I. SYMPTOMS: 1. No echoes or grass on one scope.
2. Echoes and grass on other scopes.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Coaxial cables.	1. Check the coupling and the cables between the amplifier and the blank scope.

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259. TUNING AND ALIGNMENT OF RECEIVER SYSTEM.

a. General. The i-f stages of the preamplifier, receiver, and remote video amplifier are all aligned accurately to 30 megacycles at the factory. Since a signal generator is not supplied with the test equipment and these units must be matched and interchangeable, it is not recommended that they be aligned in the field unless it is certain that alignment is needed to maintain the equipment in operation. The following general procedures should be followed:

(*1*) In the tuned circuits, the grid and plate capacitances are part of the tuned circuits. When necessary to replace tubes, try several of the spares to obtain one which produces the largest signal on the scope.

NOTE: The fact that one tube produces a larger deflection than another does not indicate that it is superior to the others. It means that its plate and grid capacities are proper for the present tuning of the circuit inductances. Matching tubes this way often makes it unnecessary to tune the inductance to the tube.

(2) If a single stage is known to be out of alignment because of repair or replacement of a part, tune that one stage to give maximum signal on the range scope.

(3) If one of the components is replaced and tube replacement will not increase the sensitivity and it is known that the unit may be out of alignment because of repairs, align that unit using the appropriate section of the procedure in the following paragraphs.

b. Preliminary Tuning Adjustments.

(1) *Tuning of T-R Box.*

(a) Turn one or both of the screw plugs at either side of the T-R box.

(b) As the T-R box is tuned towards resonance the crystal current decreases, and the echo signal increases.

(c) Lock one of the screw plugs and tune the other plug slightly to maximize the received echo.

(d) Lock the screw plug, making sure that as the plug is locked, the tuning adjustment is not disturbed.

(2) *Tuning of Local Oscillator and Crystal Mixer.* The following procedure is recommended for adjusting the local oscillator and allowing it to operate at its best operating point.

(a) Turn the local oscillator coupling to the crystal mixer counterclockwise until it is approximately three-quarters of the way out. This affords a very loose coupling which prevents the crystal from being burned out as the local oscillator tube is being tuned.

(b) Snap the FILAMENT toggle switch to the ON position.

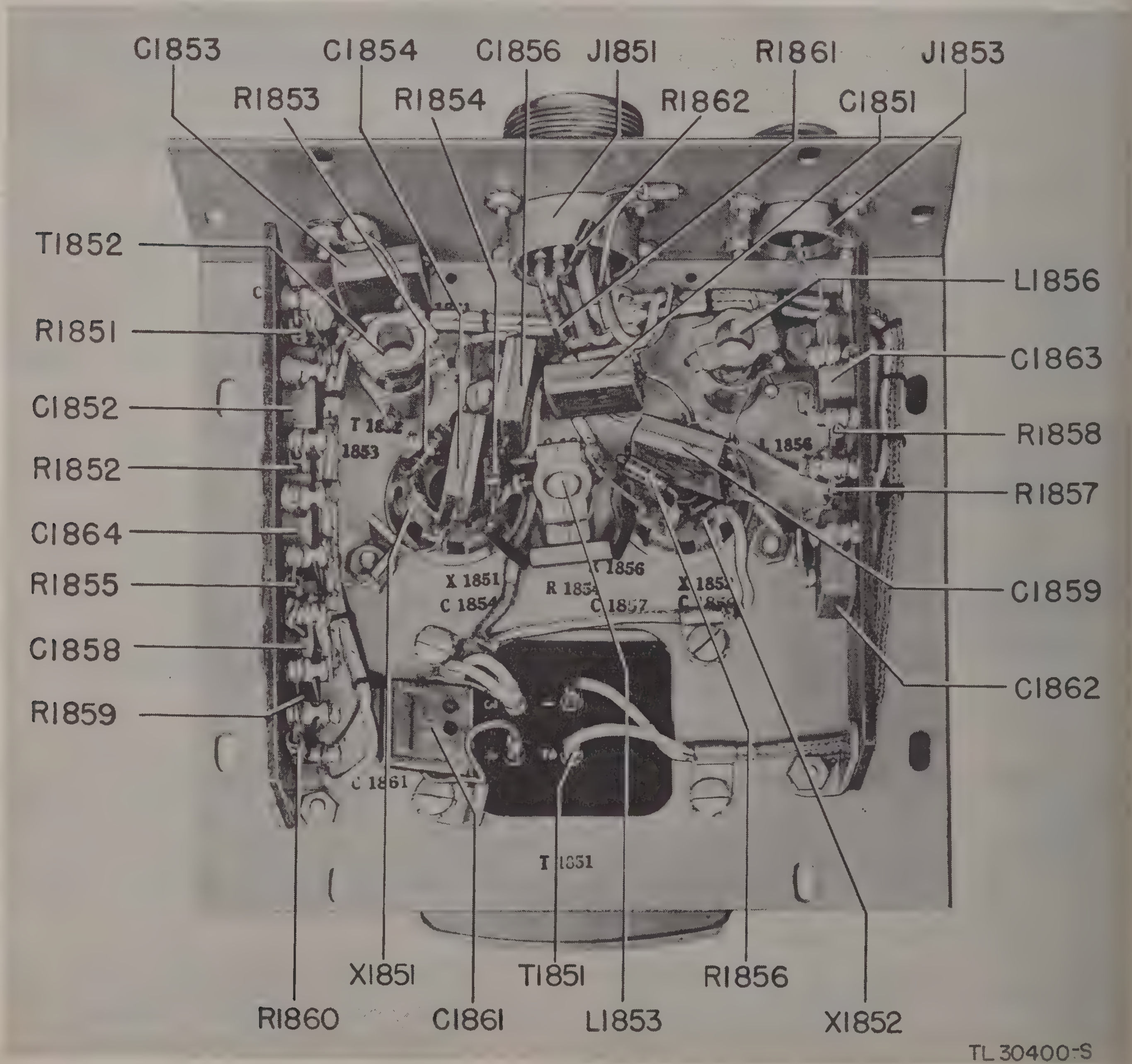


Figure 295. Preamplifier, bottom view, parts identified.

(*c*) Snap the PLATE toggle switch to the ON position.

(*d*) Set the REFLECTOR VOLTS control to 10 position.

(*e*) Connect the analyzer milliammeter between jacks J1805 and J1806 on the front panel.

(*f*) Turn the GRID VOLTS control, R1817, in a clockwise direction until the milliammeter reads about 15 ma.

(*g*) Remove the analyzer and set for voltage measurement between pin 5 of V1805 and the cathode of V1803.

(*h*) Adjust the COMP VOLTS control, R1805, until the reading is zero.

(*i*) Remove analyzer and set for 50 ma. Reconnect the meter to jacks J1805 and J1806.

(*j*) Adjust the REFLECTOR VOLTS control R1751 on the control panel until a sudden current maximum is observed on the CRYSTAL CURRENT meter indicating the klystron is oscillating. If two oscillating points are found, adjust R1751 to the point that gives the greatest maximum current.

(*k*) Readjust the GRID VOLTS control R1817 to make the maximum current reading about 18 milliamperes.

(*l*) Keeping the klystron in oscillation by means of the REFLECTOR VOLTS control, readjust the COMP VOLTS control R1806 until the voltage between pin 5 of tube V1805 and the cathode of tube V1803 is zero.

(*m*) Tune the klystron from maximum to minimum frequency by the adjustment knob on the front panel of the local oscillator. At the same time the tube must be kept in oscillation by adjusting the REFLECTOR VOLTS control R1751. This may be done by watching the meter reading. The klystron should oscillate over the entire tuning range.

(*n*) Depress switch S1766 on the control panel for at least one minute. Release switch S1766 and depress switch S1767. The motor should turn in opposite directions, and the klystron should still remain in oscillation.

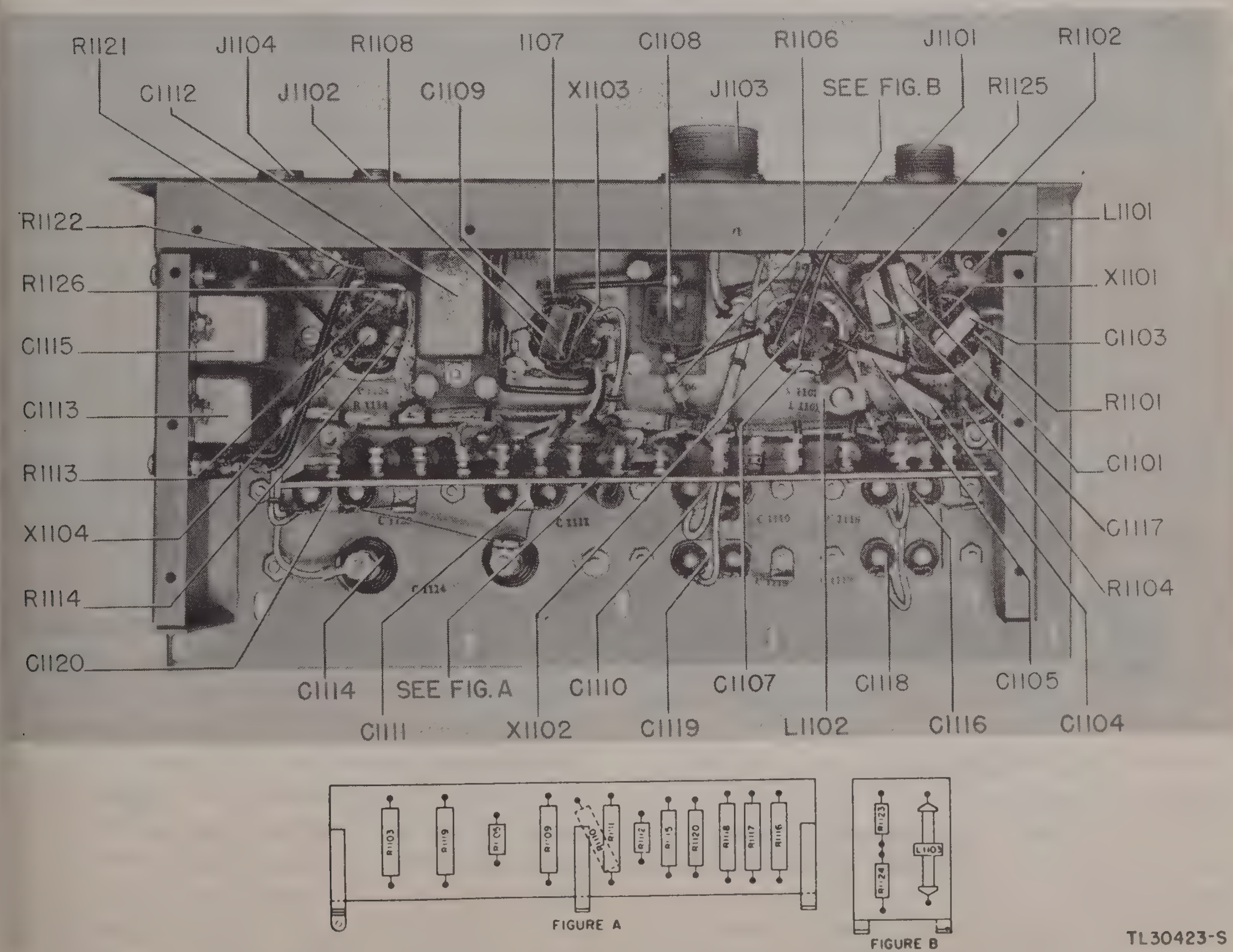


Figure 296. Remote video amplifier, bottom view, parts identified.

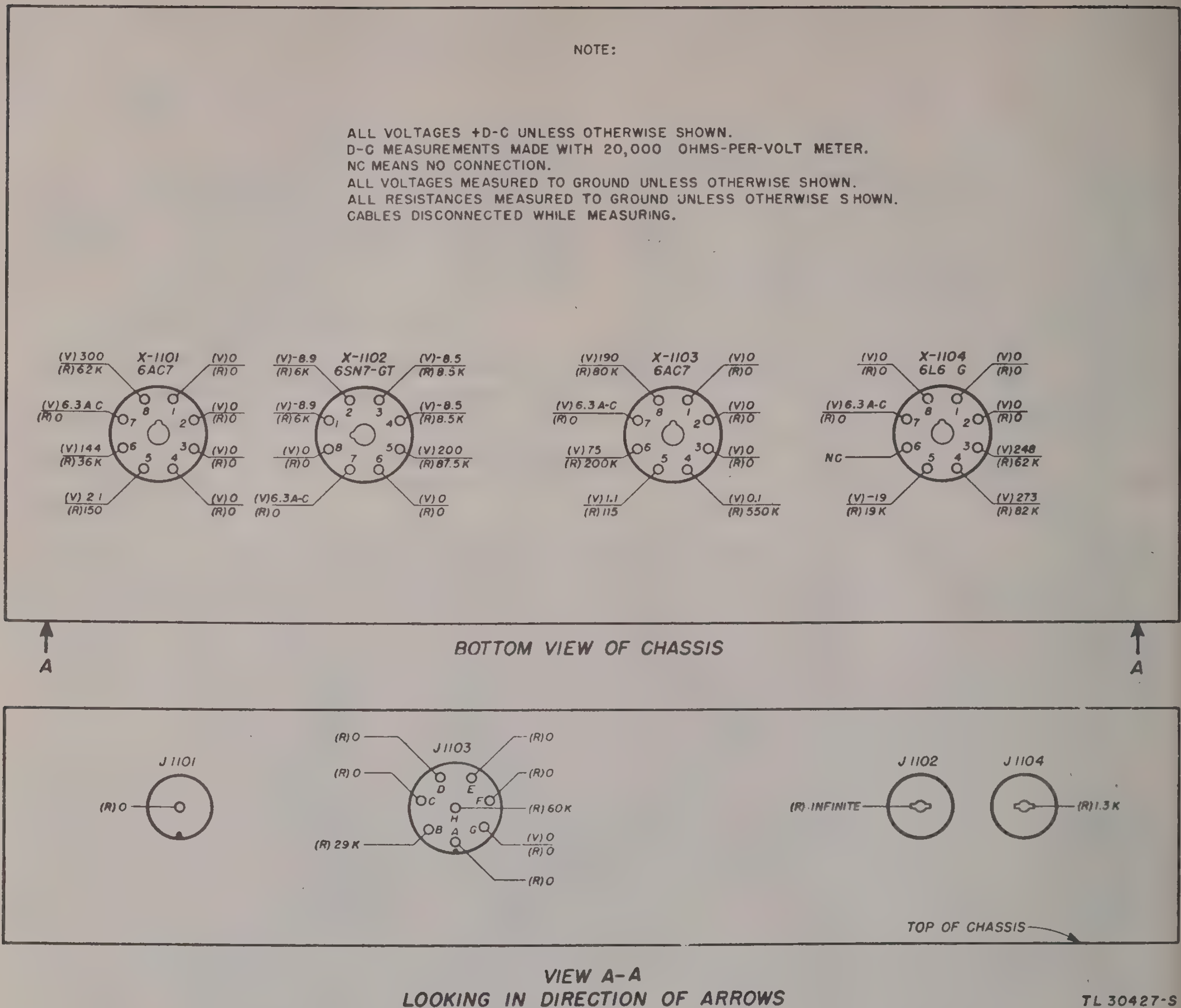


Figure 297. Remote video amplifier, voltage and resistance chart.

(*o*) Turn the coupling, of the klystron to the crystal mixer, slowly clockwise to give a reading of 0.15 to 0.5 ma. The current should never exceed this figure.

(*3*) *Tuning of AGC Circuit.* The automatic gain control circuit is adjusted to secure the maximum gain for minimum signal. For maximum gain the AGC bias voltage is zero volts, set in the following manner:

(*a*) Remove the 3d i-f amplifier tube V701.

(*b*) Turn the control panel switch to MANUAL position.

(*c*) Turn the AGC switch to OFF.

(*d*) Set the VOLUME control for maximum gain.

(*e*) Adjust the AGC ADJ control to give zero volts at the grid (pin 4) of tube V701.

(*4*) *Adjustment of the Voltage Regulator Circuit.*

(*a*) Remove the 3d i-f tube V701.

(*b*) Set the VOLT REG ADJ to give 120 volts at the screen grid (pin 6) of tube V701.

c. Tuning Procedure.

(*1*) Make the necessary preliminary tuning adjustments as described in subparagraph **b** above. Set the AGC switch to the OFF position and turn the VOLUME control maximum clockwise.

(*2*) If the system is known to be completely out of alignment, measure the transmitter frequency as described in paragraph 224 with the echo box.

(*3*) Measure the local oscillator frequency with the echo box (par. 226) and tune the local

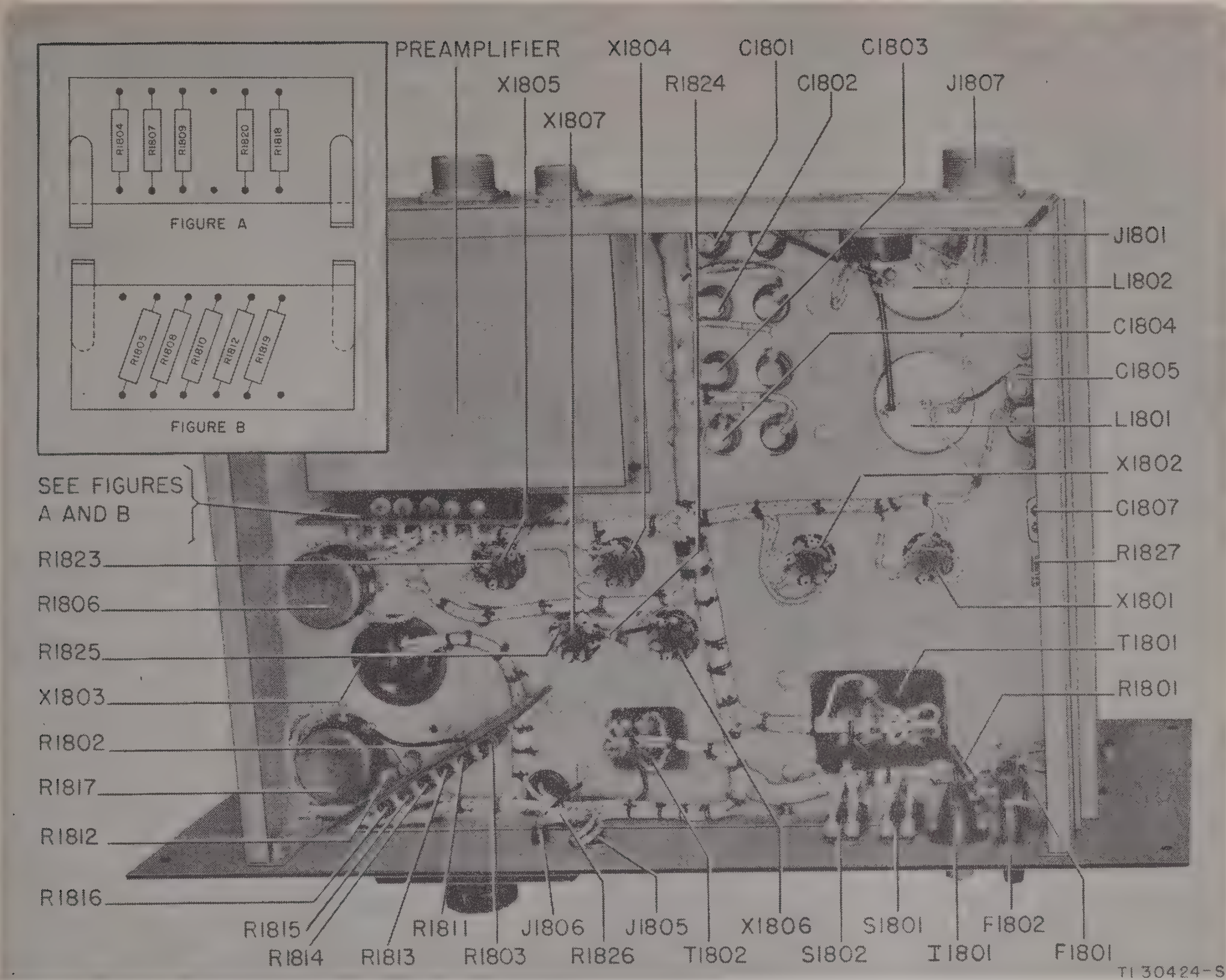


Figure 298. Local oscillator, bottom view, parts identified.

oscillator as described in subparagraph **b** (*1*) above to 30 megacycles above or below the transmitter frequency.

(*4*) The receiving system should now be sufficiently aligned so that some broadening of the main pulse on the 32,000- or 2,000-yard range scope can be visible. Further tune the r-f and receiving system as described in paragraph 222 for maximum ringing time.

(*5*) The system should now be sufficiently aligned so that a strong fixed echo can be used for further rough tuning and then a more distant echo can be used for fine tuning adjustments.

(*6*) Rotate the antenna until a known fixed echo is received on the 32,000-yard scope and move the range hairlines so that the echo may be observed on the 2,000-yard scope. Position the antenna to maximize the echo.

(*7*) Tune the local oscillator by means of the push buttons to give a maximum echo signal. Adjust the REFLECTOR VOLTS control to keep the crystal current at a maximum. Reduce the VOLUME control as necessary to keep the echo below saturation. Set the line, cut on the surface of the cam, which is turned by the local oscillator tuning motor, so that one end touches the lever arm (fig. 61). This sets the local oscillator frequency at the center of the oscillator tuning motor range. Turn the FREQ ADJUST knob on the front of the local oscillator to see if the echo signal can be further maximized. If the knob is at the end of its travel, bring the knob back to the midpoint of its travel, and adjust the three coarse tuning screws on top of the local oscillator tube. These screws are a coarse frequency adjustment and must be turned very slowing while observing the echo on the range scopes. Retune the FREQ ADJUST knob for maximum echo height.

(*8*) Loosen the coupling loop from the T-R

box to the mixer and rotate the coupling loop for maximum echo. Tighten the mixer input coupling.

(*9*) Tune the T-R box for maximum echo signal as described above (subpar. **b** (1)).

(*10*) If the i-f stages are out of alignment connect the test oscilloscope into jack J702 in place of the cable to the automatic tracking unit. Adjust tuning coils in the following order for maximum video signal: L706, L705, L704, L703, L702, L701 of the receiver; L1856, L1853, T1852 of the preamplifier. These coils should be adjusted smoothly and slowly. Then remove the test scope and tune L1102 in the remote video amplifier and L708 in the receiver for maximum echo on the range scope.

(*11*) Retune the local oscillator.

NOTE: The local oscillator tuning drifts slightly as the klystron warms up. It is necessary to retune the oscillator after the warm-up period.

(*12*) Tune the local oscillator crystal coupling until the target echo is at a maximum, with the grass at a minimum. As the coupling is increased both the target echo and the grass increases in magnitude. When an increase in crystal coupling only increases the magnitude of the grass, and not the target echo, the correct position of the local oscillator crystal coupling is obtained.

(*13*) Repeat steps 7 through 12 for maximum echo height.

(*14*) Replace the crystal if a poor crystal was used during the initial turning procedure.

(*15*) Check the action of the VOLUME control by the indications of the automatic tracking unit meter. When counterclockwise, the meter should read full scale. When clockwise, the meter reading should be slightly reduced. The strength of the echoes on the range scope should vary.

(*16*) Snap the receiver AGC switch to AGC. The meter reading of the automatic tracking unit should be between 5 and 9 ma. The signals on the range scopes should not be saturated.

(*17*) Move the narrow gate off the signal, the gain of the receiver should increase and the grass on the scope should exceed ⅛ of an inch.

d. Tuning the Receiving System With the Echo Box. The tune up of the receiving system may be given an additional check with the echo box. The echo box is also useful in obtaining a comparative check of the tune up at periodic intervals. In making this comparison great care must be taken to have the antenna aimed directly at the echo box dipole, to have the spinner motor stopped, and antenna dipole parallel to the echo box dipole. Comparisons should not be made using different transmitting oscillators as the ringing time of the box varies greatly with frequency (par. 222). For complete details on tuning the receiving system with the echo box see paragraph 222.

260. REPLACEMENT OF PARTS.

a. Replacement of Local Oscillator.

(*1*) Disconnect the two r-f cables from the output terminals of the klystron.

(*2*) Remove the local oscillator chassis from the rack.

(*3*) Remove the reflector connections from the klystron tube cap on top of the tube.

(*4*) Remove the screws which hold the klystron to the yoke.

(*5*) Reach under the chassis and grasp the socket, holding the klystron firmly by the lower part of the tube with the other hand. Remove the klystron from its socket.

(*6*) Replace the new tube, without forcing it into the socket.

(*7*) Screw the klystron to the mounting yoke.

(*8*) Replace the reflector connection on cap of tube and replace the chassis in the rack.

(*9*) Reconnect the two r-f cables to the klystron terminals.

b. Replacement of Crystal (figs. 63 and 64). Most of the symptoms of trouble in the crystal mixer show up as general defects in the receiving system, and are covered in the trouble-shooting sections. The chief source of trouble is the crystal, which is very delicate and sensitive. It is easily damaged by excessive current.

(*1*) Remove the i-f output lead to the preamplifier.

(*2*) Unscrew the knurled coupling nut next to the i-f output, removing the output fitting.

(*3*) Remove the crystal taking care not to damage the crystal contact springs.

(*4*) Install a new crystal, keeping it shorted with the fingers, and touch the assembly before releasing the short.

(*5*) Make sure the crystal makes good contact with the springs, but do not force the crystal if it does not slide in place with a light pressure. Inspect the spring contacts.

(*6*) Replace the coupling fitting.

(*7*) Replace the output lead to the preamplifier.

NOTE: When installing a new crystal, always adjust the mixer coupling so that minimum coupling is obtained. The knurled knob should be turned in a counterclockwise direction. After the new crystal is installed the knob should be turned in a clockwise direction until the coupling is sufficient to produce a proper flow of crystal current. Do not remove the protective lead foil wrapping until ready to place the crystal in the crystal mixer.

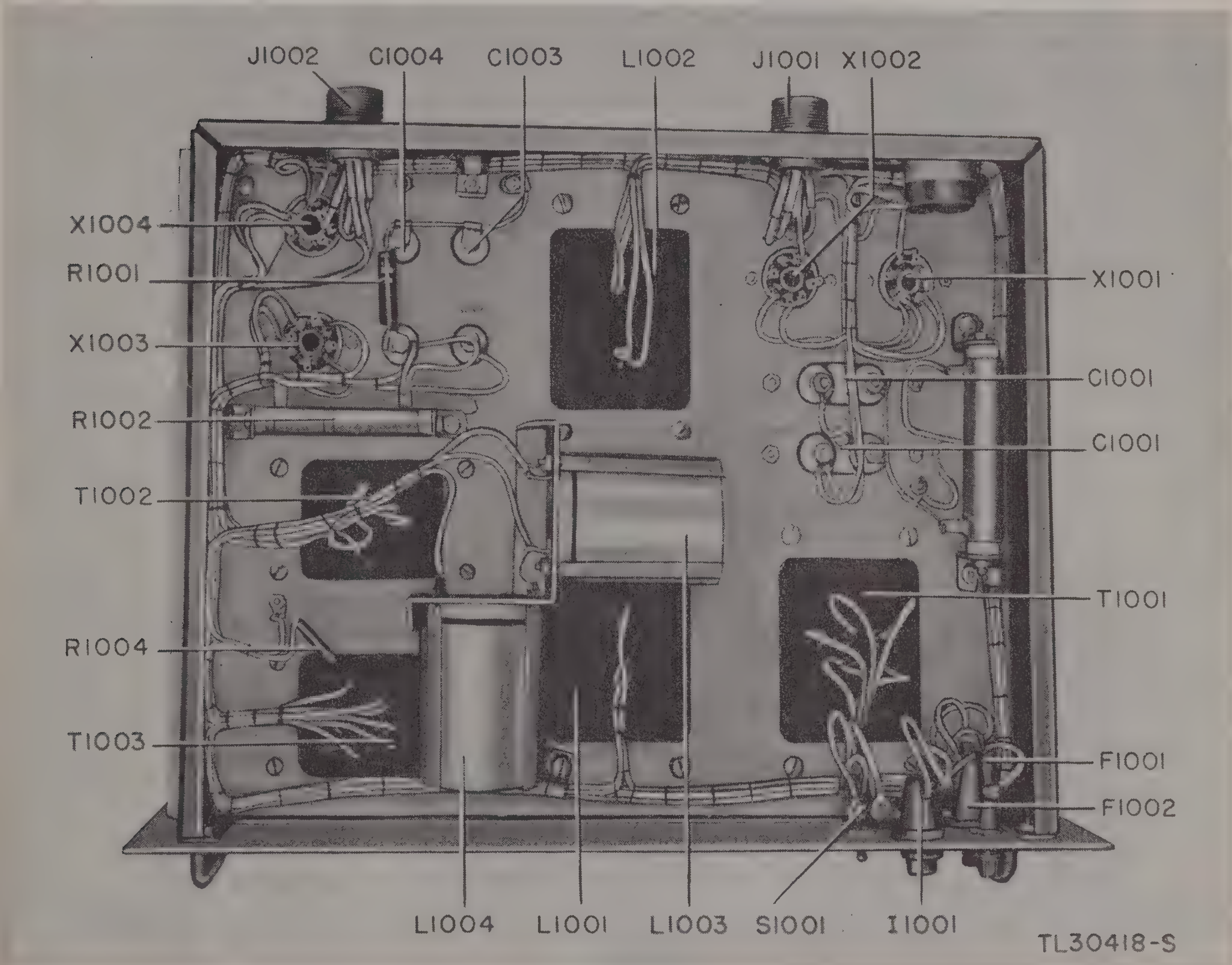
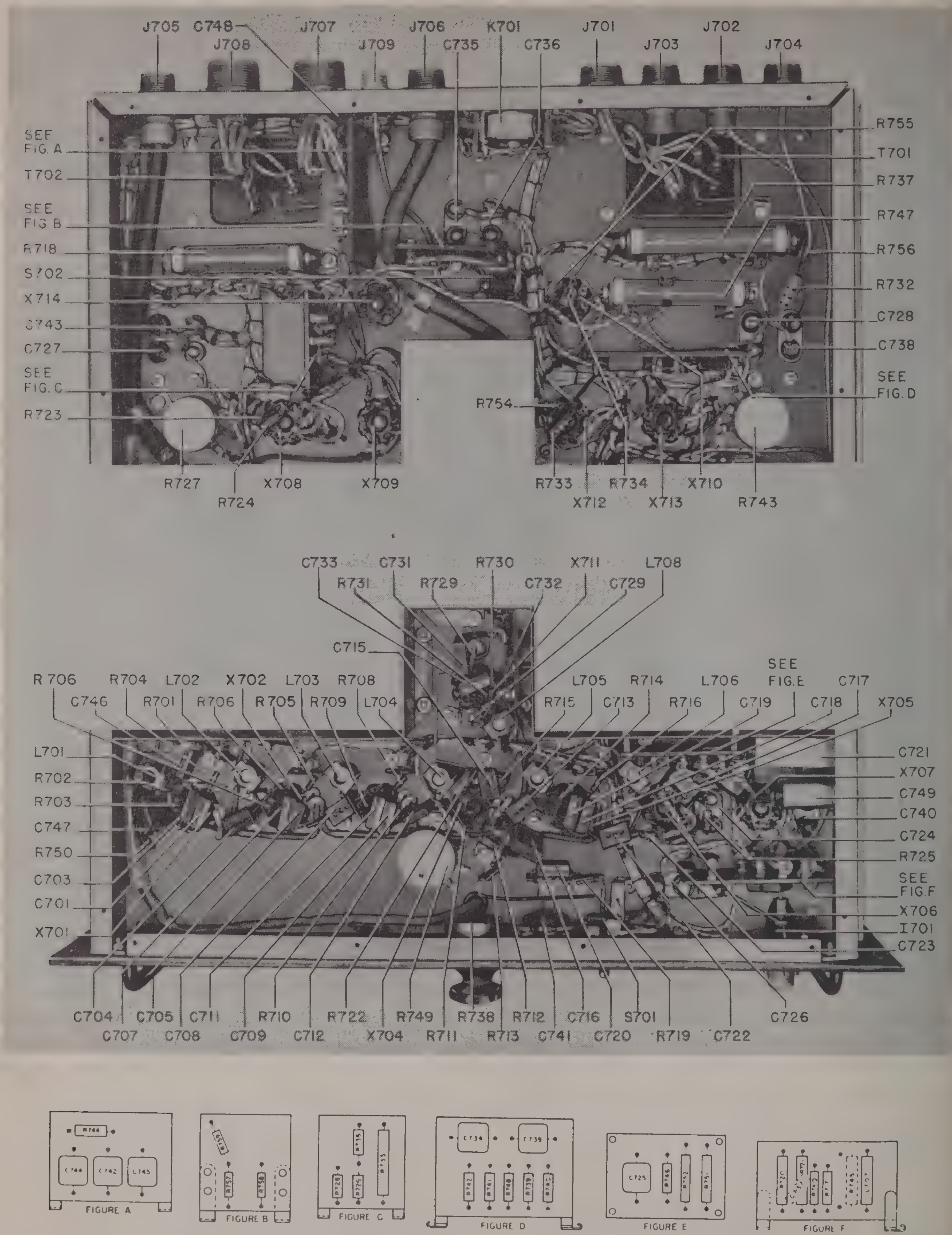
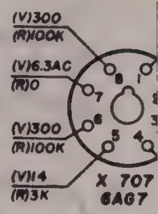


Figure 299. Receiver power supply, bottom view, parts identified.



TL 30409-S

Figure 300. Receiver, bottom view, parts identified.



CONDITIONS OF MEASUREMENT
USE 115 V EXTENTION CABLE (TC I W 2101)
CHASSIS FROM ANY CONVENIENT PLUG.
SET CURRENT MEASURED BETWEEN J18(
WITH R 1817, WHILE KLYSTRON IS OSCILL/
MAINTAIN INPUT AT 115 V AC.

NOTE:
* USE CAUTION WHEN MEASURING HIGH \
ALL VOLTAGES MEASURED TO GROUND UN
ALL VOLTAGES +D-C UNLESS OTHERWISE S
D-C MEASUREMENTS MADE WITH 20,000
NC DENOTES NO CONNECTION.

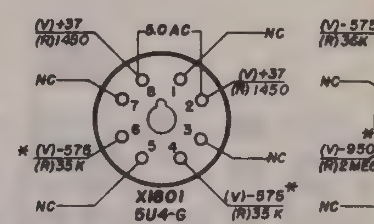


Figure 302. Local oscillator, voltage and resistance chart.

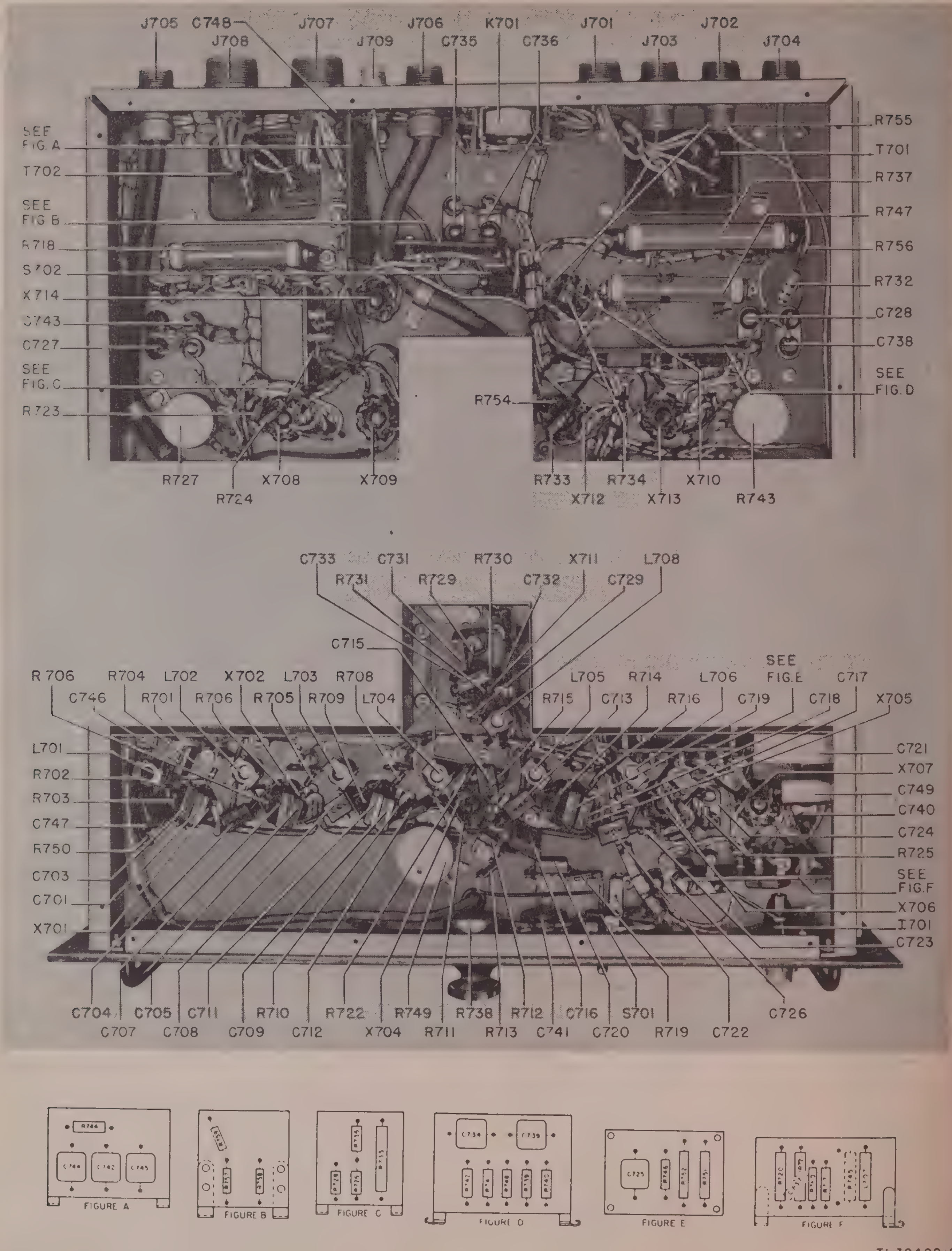


Figure 300. Receiver, bottom view, parts identified.

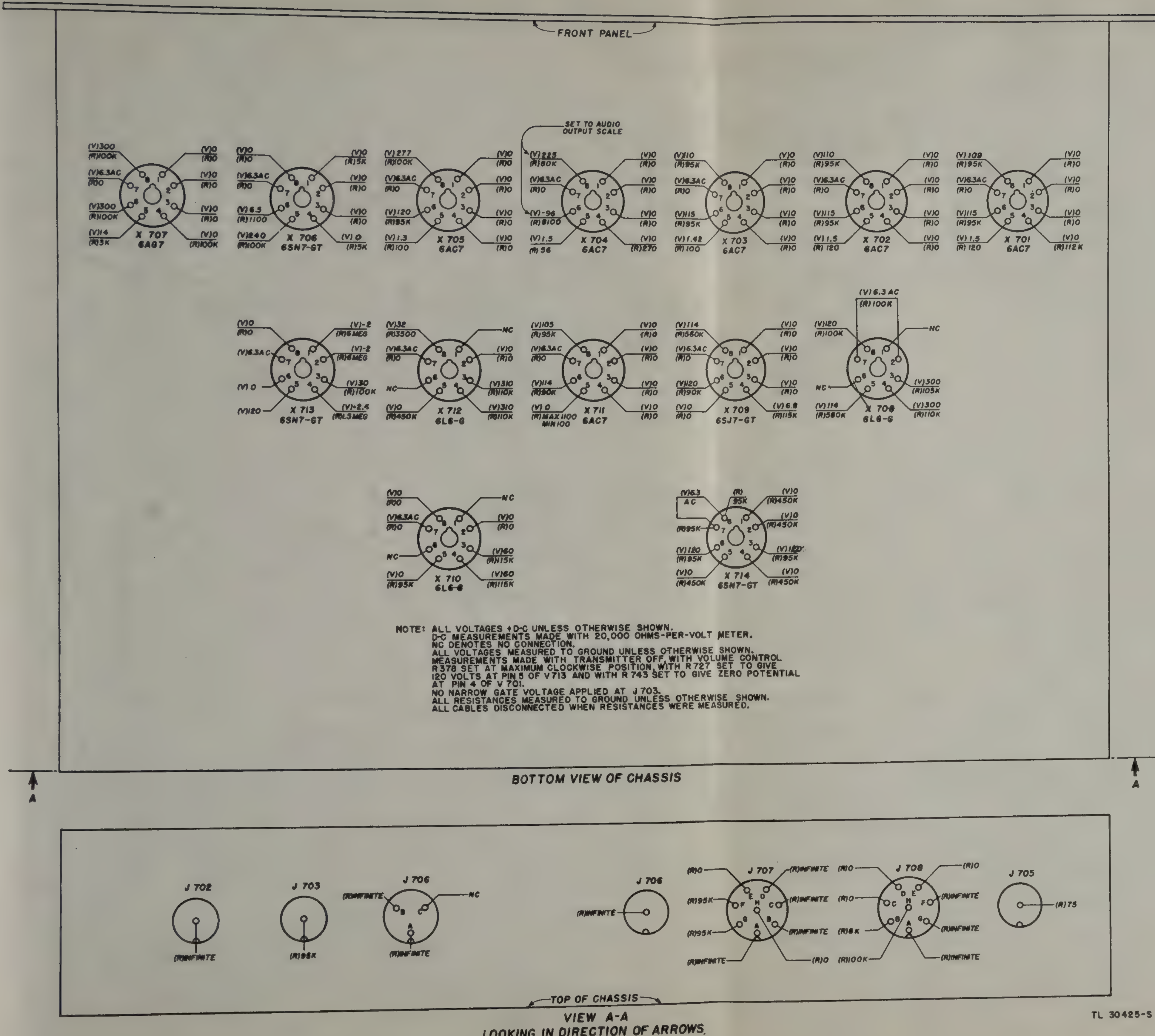


Figure 301. Receiver, voltage and resistance chart.

Figure 301. Receiver, voltage and resistance chart.

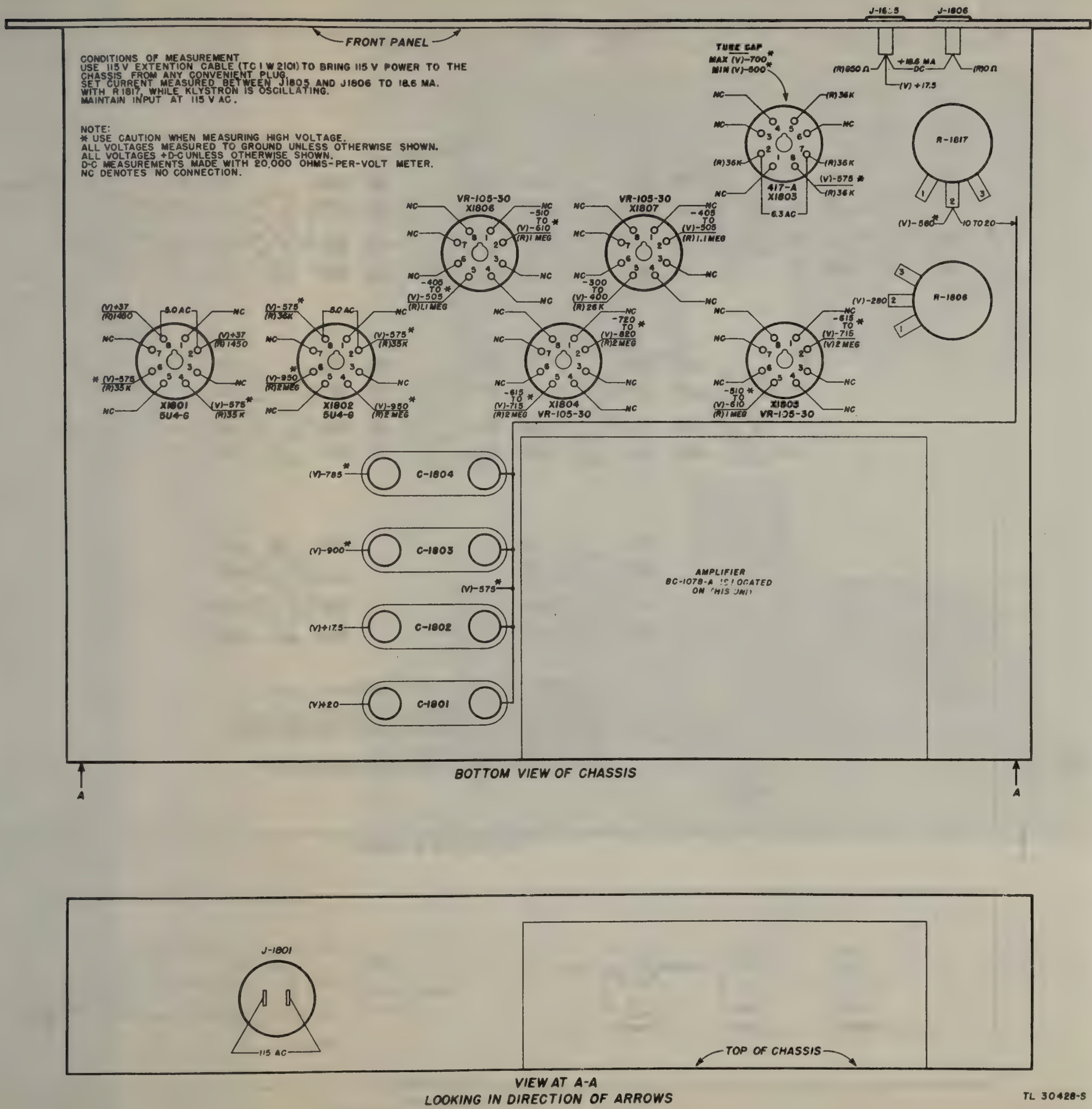


Figure 302. Local oscillator, voltage and resistance chart.

Figure 302. Local oscillator, voltage and resistance chart.

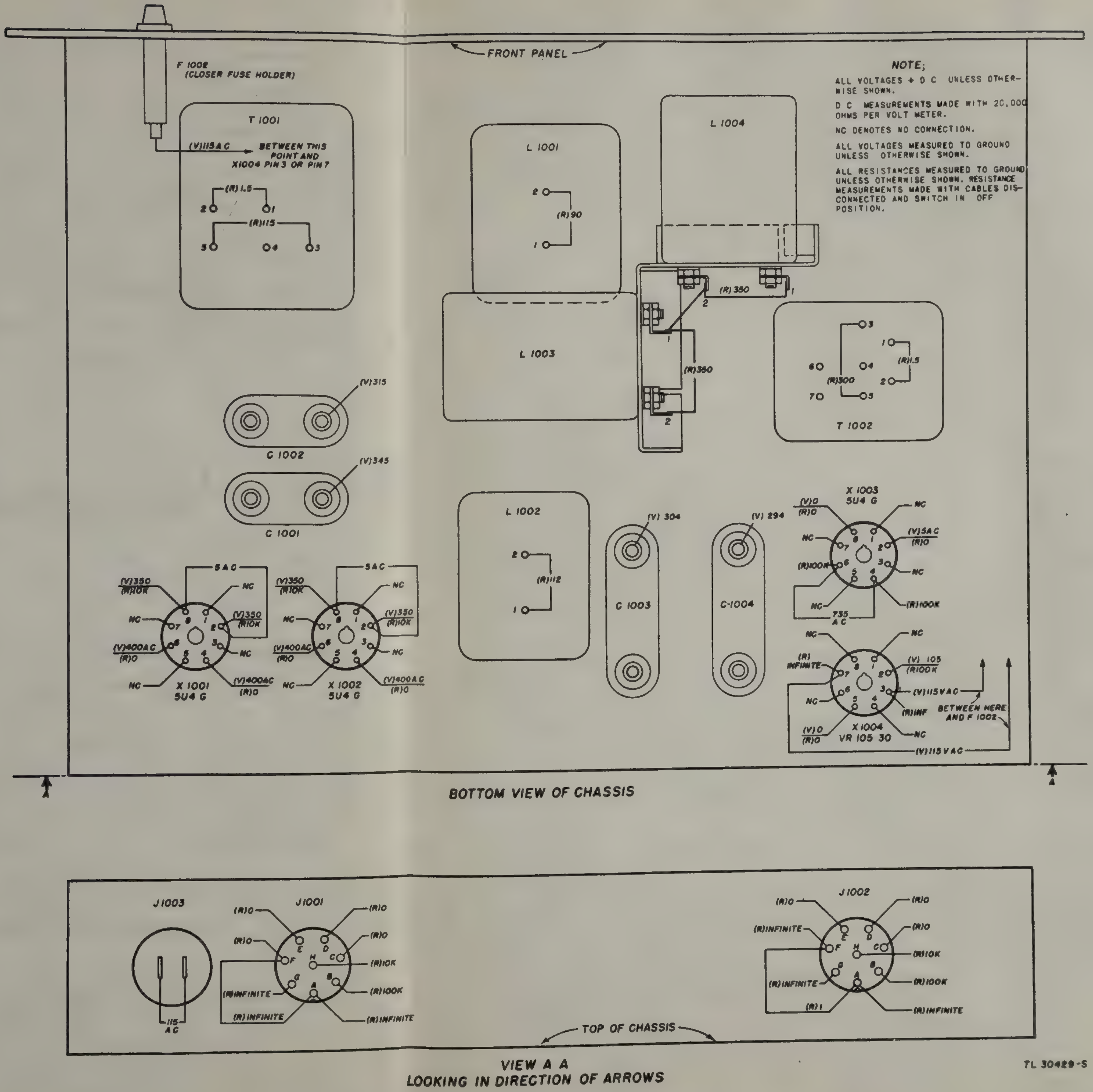


Figure 303. Receiver power supply, voltage and resistance chart.

Figure 303. Receiver power supply, voltage and resistance chart.

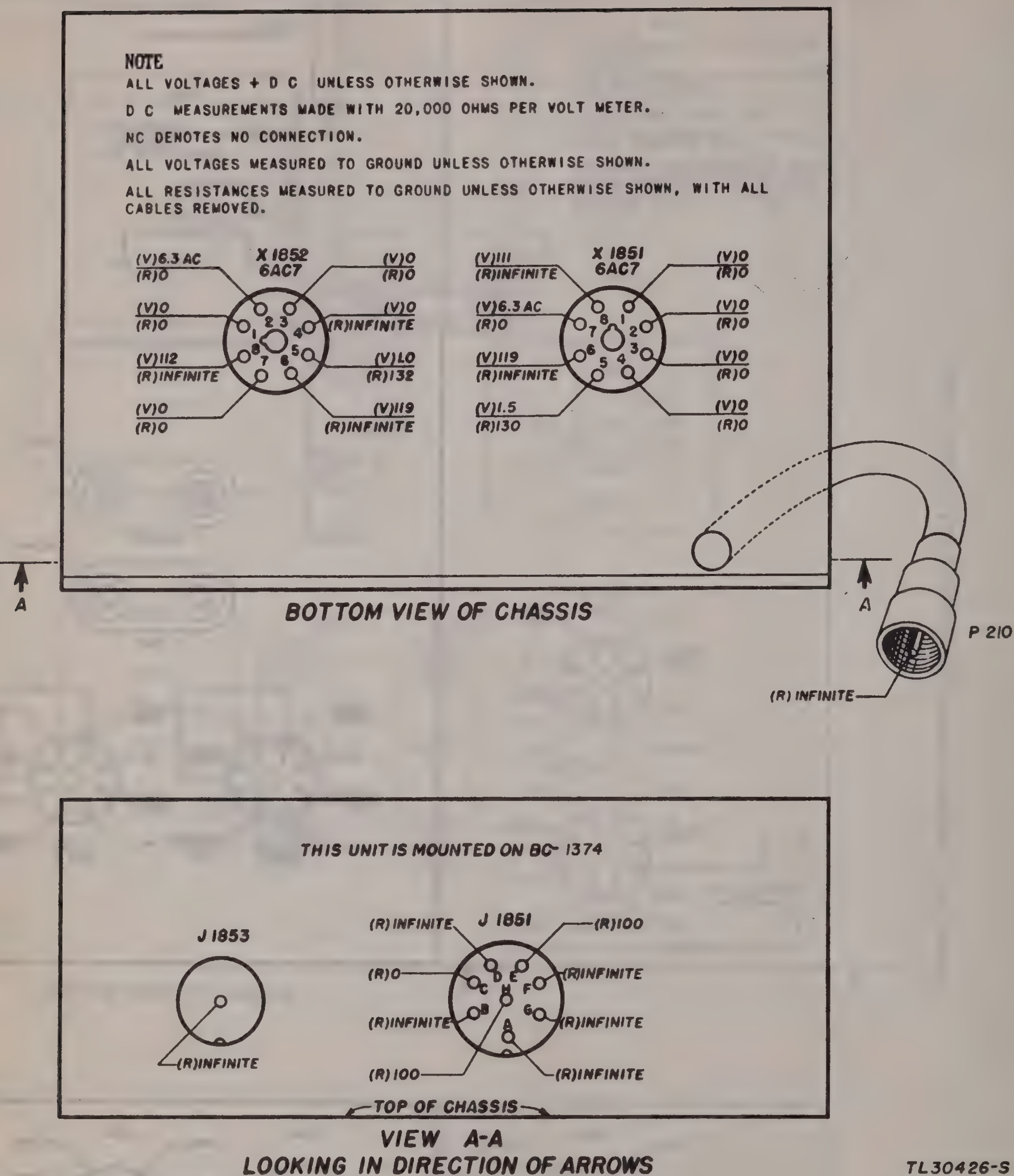


Figure 304. Preamplifier, voltage and resistance chart.

CHAPTER 16
TROUBLE SHOOTING IN THE RANGE SYSTEM

SECTION I
TROUBLE SHOOTING

WARNING: *Voltages sufficient to cause death on contact are exposed in the range indicator and the range power supply. Do not place hands within these units with the high voltage on. Always ground high-voltage capacitors before touching them or their associated parts.*

261. REFERENCE DATA.

The following figures will be of aid to radar maintenance personnel while trouble shooting in the range system:

a. Range System.
Figures 84 and 85. Block diagram.
Figure 87. Range system cabling diagram.

b. Range Unit.
Figure 90. Block diagram.
Figure 305. Bottom view.
Figure 141. Schematic diagram.
Figure 306. Voltages and resistances.
Figure 320. Waveforms.

c. Range Indicator.
Figure 108. Block diagram.
Figure 309, Bottom view.
Figure 315. Left side.
Figure 314. Right side.
Figure 310. Rear view.
Figure 142. Schematic diagram.
Figure 311. Voltages and resistances.

d. ART Unit.
Figure 117. Block diagram.
Figure 313. Bottom view.
Figure 143. Schematic diagram.
Figure 312. Voltages and resistances.
Figure 321. Waveforms.

e. Range Power.
Figure 308. Bottom view.
Figure 144. Schematic diagram.
Figure 307. Voltages and resistances.

f. Automatic Range Tracking Power Unit.
Figure 317. Bottom view.
Figure 145. Schematic diagram.
Figure 318. Voltages and resistances.

g. ART Oscillator Phase Shifter.
Figure 316. Rear view.

262. TROUBLE SHOOTING WITH RANGE INDICATOR.

Troubles in the range system become apparent as distorted sweeps on the range indicator tubes, or as erratic range data. Some troubles in the range system also give indications in other systems of the radar set, because the transmitter and the PPI systems are triggered by circuits in the range unit. Isolating troubles in the range system can be done using the test points on the chassis in the range system and the range indicator scopes as the test scopes. A thorough knowledge of the test points, the waveforms to be expected at those points, and the significance of those waveforms is a great aid to the trouble shooter. To view the test waveforms on the range scopes, test cable W2118 should be connected from the MONITOR jack J911 on the range indicator to the test jack under observation. For most tests, the switches on the rear of the range indicator, range unit, and receiver should be set to NORMAL. Set the NARROW GATE WIDTH and the WIDE GATE WIDTH controls to minimum. Advance the scope INTENSITY controls to make the sweep lines visible. To view the narrow and wide gates on the range scopes, the gate width controls have to be set so that some output can be seen. This output blurs the trace on the scopes unless the gate output cables are disconnected from jacks J909 (narrow gate) and J907 (wide gate).

263. RANGE UNIT TEST POINTS.

a. Test Jack J611. The heart of the whole radar set is the crystal oscillator in the range unit. When the crystal oscillator is operating, it must operate at the proper frequency, for the crystal forces the tube to oscillate at only one frequency. Therefore, if the oscillator is operating at all, the sweep line on the 2,000-yard range scope should be normal. A distorted sweep line on the 2,000-yard scope can only be caused by a fault in the 2,000-yard sweep transformers in the range unit or the range indicator, or in the sweep cable between units. Absence of sweep on the 2,000-yard scope can be caused by an inoperative crystal oscillator or by faults in the sweep circuits or cable. By connecting the test lead to jack J611 the presence of the 81.94-kc oscillator output (fig. 320**a**) can be detected by noting either motion of the spot on the scope screen or by displacement of the distorted sweep line. No signal at test point J611 can be caused only by a fault in the crystal oscillator stage; so if an abnormal waveform is found at test jack J611, a voltage-resistance check should be made of that stage to discover the faulty element.

b. Test Jack J622. The output of the crystal oscillator is distorted to form the trigger that synchronizes the 20-kc multivibrator and provides the trigger input to the trigger selector tube. If this stage is inoperative, the 32,000-yard sweep is distorted (the frequency divider multivibrators run at a nonsynchronous frequency) and the transmitter, PPI, and gate circuits in the automatic range tracking unit are inoperative (there will be no trigger to those units from the range unit). The output of the trigger generator stage as observed on the 32,000-yard scope is shown in figure 320**a**.

c. Test Jack J612. The 20-kc multivibrator is the first of three frequency dividing multivibrators. A fault in this stage will not affect the 2,000-yard scope, for the 2,000-yard sweep is generated by the crystal oscillator stage which preceded the 20-kc multivibrator, and the scope unblanking circuits (narrow gate multivibrators) are triggered by the free running frequency dividing multivibrators. A fault in the 20-kc multivibrator causes the 32,000-yard sweep line to become distorted, for the 32,000-yard sweep transformer will no longer have the correct frequency input. By connecting the test lead to test jack J612, the frequency of the 20-kc multivibrator can be checked. When it is operating properly, the 20-kc multivibrator divides the crystal frequency by four; so four lines should appear on the 2,000-yard scope. When observing the waveform at test jack J612, the 20-KC MV control should be so adjusted that the multivibrator is operating at the center of the range of proper operation. The pattern on the 32,000-yard scope depends upon both the 20-kc multivibrator output on the signal electrode of the scope and the 5-kc multivibrator that generates the sweep voltages; so it should not be used for checking the output of the 20-kc multivibrator. When the proper pattern has been obtained on the 2,000-yard scope with the test lead in jack J612, the wave form on the 32,000-yard scope should be as shown in figure 320**a**, providing the 5-kc multivibrator is working at the proper frequency to provide the circular sweep for the 32,000-yard scope. If no sweep line exists on the 32,000-yard scope, and the only motion of the spot seems to be due to the 20-kc multivibrator output on the signal electrode of the scope, either the 5-kc multivibrator or the 5-kc amplifier is at fault.

d. Test Jack J613. The 20-kc multivibrator drives the 5-kc multivibrator at a frequency exactly ¼ that of the 20-kc multivibrator. Since the sweep frequency applied to the 32,000-yard scope tube and the signal at test jack J613 are both 5 kc, only one cycle of the multivibrator output appears on the 32,000-yard scope as shown in figure 320**a**. If there is no sweep line on the 32,000-yard scope, observation of the 2,000-yard scope indicates whether the trouble is in the 5-kc multivibrator or in the 5-kc sweep circuits. A fault in the sweep circuits causes an absence of trace on the 32,000-yard scope, but does not prevent the 5-kc multivibrator output from appearing on the 2,000-yard scope. Therefore, if a spiral with sixteen lines appears on the 2,000-yard scope, the 5-kc multivibrator is operating properly, regardless of whether or not there is a waveform on the 32,000-yard scope. No signal on either scope indicates a fault in the 5-kc multivibrator.

e. Test Jack J614. If the 1.7-kc multivibrator were inoperative, the narrow gate, wide gate, and trigger gate width and delay multivibrators would not operate. This would result in apparent loss of sweep in the two range indicators and loss of trigger to the transmitter, PPI, and automatic range tracking unit. However, by turning up the intensity controls on the scopes, a

circular sweep should appear. By checking for the output at test jack J614 the cause for such a fault can be isolated to either the 1.7-kc multivibrator or to the clipper. The waveform of the multivibrator output as seen from test jack J614 is shown in figure 320**a**.

f. Test Jack J615. The purpose of the 1.7-kc clipper is to square the output of the 1.7-kc multivibrator and thus provide a steep wave front to trigger the delay multivibrators. Erratic operation of these delay multivibrators could result from faulty clipper operation. A check of the waveform at test jack J615 should indicate the operation of the clipper stage. The normal clipper output is shown in figure 320**a**.

g. Test Jack J616. Absence of the narrow gate on the fine range scope during NORMAL operation, and absence of the gate marker on the PPI scope indicates trouble in the narrow gate multivibrators. The output of the narrow gate delay multivibrator is seen on jack J616 and appears as shown in figure 320**a** (range maximum and 320**b** range minimum) on the coarse range scope.

h. Test Jack J625. The output of the narrow gate width multivibrator is seen by connecting the test lead to jack J625. The narrow gate is viewed on the 32,000-yard scope, figure 320**b**, and its width and position should be variable by turning the narrow gate delay and width controls on the range unit, and the handwheel on the range indicator.

i. Test Jack J617. Absence of the wide gate brightening pulse on the 32,000-yard scope during operation of the range indicator unit indicates trouble in the wide gate multivibrators. Operation of the wide gate delay multivibrator can be checked by testing the waveform of the voltage appearing at test jack J617. Normal waveforms with the delay at a maximum and at a minimum are shown in figure 320**b**.

j. Test Jack J624. The output of the wide gate width multivibrator appears at test jack J624. The normal waveform for this test point is shown in figure 320**b**.

k. Test Jack J618. Absence of a trigger to the transmitter, PPI, and automatic range tracking unit with an otherwise normal range system indicates trouble in the trigger gate multivibrators, the trigger gate cathode follower, or the trigger selector stage. A faulty trigger gate delay multivibrator can be detected by observing the waveform at test jack J618. The normal waveform for this jack is shown in figure 320**b**.

l. Test Jack J623. The output of the trigger gate width multivibrator is not brought out directly to a test jack, but test jack J623 shows the output of this multivibrator as taken from the trigger gate cathode follower stage V613A. The normal waveform for this jack is shown in figure 320**b**. The small dip in the gate waveform is caused by screen current that flows when the trigger is applied to the grid. This dip should occur at the center of the pulse.

m. Test Jack J620. The output of the trigger selector tube, the trigger that starts the transmitter range tracking unit, and the plan position unit, can be seen at test jack J620. This waveform should occur at the position indicated in figure 320**b** and should be approximately the same shape as in the figure.

n. Test Jacks J619 and J621. These two test jacks are d-c jacks only. Before the range unit is aligned, the voltages at these jacks should be checked. The voltage at J621 is the trigger selector screen bias and cannot be adjusted. This voltage is normal if it is less than −14.5 volts. The voltage at jack J619 should be +250 volts. This voltage is set by the regulator control VOLT REG ADJ on the range power unit.

264. ART UNIT TEST POINTS.

As in the range unit, the waveforms (fig. 321) on the auto range unit are best observed on the range indicator scopes. The narrow and wide gate width controls on the range unit should be set to minimum width, the ART-NORMAL switch on the rear of the range indicator should be set at NORMAL, and the intensity controls on the range indicator set to give a visible sweep. Test cable W2118 should be connected from jack J911 on the range indicator to the test jack on the auto range unit. The remote video amplifier cable may be used as an extension cable if desired.

a. Test Jack J2112. All the circuits in the auto range unit depend upon the output of the input multivibrator for their operation. If the input multivibrator is inoperative, the N^2 gate mark and the illuminating gate will not brighten the sweep line on the range indicators when the switch on the rear of the indicator is set to the ART position. Test jack J2112 provides a means for checking the output of the input multivibrator as taken from tube V2111A. If the proper waveform, figure 321, appears at test jack J2112, but the fine range scope during ART operation indicates that there is neither an illuminating

gate nor N^2 gate being generated, the fault must be in the circuit of the saw-tooth delay, the amplifier, or the illuminating gate generator. Operation of the saw-tooth delay circuit can best be checked by removing tube V2106 and inserting the test prod in pin hole 4, the grid terminal. The waveform should be as shown in figure 321. The differentiator and amplifier may be checked by removing V2113 and checking for the correct waveform at pin 1 (fig. 321).

b. Test Jack J2115. The waveform of the illuminating gate may be checked by plugging the test lead into test jack J2115. The operation of the N^2 gate generator depends upon the leading edge of this output after it is delayed by the delay line L2105, L2106, and L2107. For proper triggering the N^2 gate generator, the waveform should be as shown in figure 321.

c. Test Jack J2116. The N^2 gate, before it is delayed by L2104, is used in the receiver to operate the servo channel. Proper receiver operation requires a sharp waveform as shown in figure 321.

d. Test Jack J2117. The N^2 gate from the N^2 gate generator is delayed by L2104 and is used in the servo and gate trackers. Faulty operation of these circuits would cause a distorted waveform to appear at jack J2117. The normal waveform is shown in figure 321.

e. Test Jacks J2113 and J2114.

(*1*) With the range tracking switch on the control panel set to the MANUAL position, the waveform at these test jacks should be as shown in figure 321. This is the 410-kc sine wave that is applied to the gate tracker during manual tracking and should give a check on the operation of the 410-kc oscillator and phase shifter. Rotating the slewing handwheel should cause the humps on the sweepline to progress around the face of the tube without changing in amplitude.

(*2*) With the range tracking switch on the control panel set to AUTOMATIC, the waveform at these test points should be a narrow video pip. To get a signal for the video peaker to operate on, disconnect the trigger cable from the jack J2109 and connect that cable to the video input jack J2108. This gives a trigger that is useful in observing the operation of the video peaker. A target on the 2,000-yard scope should appear as shown in figure 321 when the ART unit is working properly.

265. RANGE SYSTEM, TROUBLE-SHOOTING CHART—NORMAL OR NARROW GATE OPERATION.

A. SYMPTOMS:
1. No 2,000-yd sweep.
2. 32,000-yd sweep distorted.
3. Transmitter inoperative.
4. No PPI sweep.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Crystal.	1. Turn the CRYSTAL SELECTOR switch to the alternative position to switch in the spare crystal.
2. Oscillator.	2*a*. Replace the oscillator tube.
	b. Measure the plate supply voltage at J619 with the test analyzer. It should be approximately 250 volts dc. If not normal, make a voltage and resistance check of the crystal oscillator stage and T601 (fig. 306).

B. SYMPTOMS:
1. 32,000-yd sweep small, distorted.
2. 2,000-yd sweep normal size.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. 20-kc multivibrator.	1*a*. Check the waveform at J612 (output of 20-kc multivibrator). If this waveform is not locked to the crystal (does not show 4 rings), try adjusting the 20-KC MV control to secure the pattern shown in figure 320**a**.

	Only slight adjustment of the control should be necessary.
	b. Replace the multivibrator tube.
	c. Make a voltage and resistance check of the stage (fig. 306).
2. 5-kc multivibrator.	2*a.* Check the waveform at J613 (output of 5-kc multivibrator). If this waveform is not locked (does not give stable pattern as shown in figure 320**a**) try adjusting the 5-KC MV control. Only slight adjustment of the control should be necessary.
	b. Replace the multivibrator tube.
	c. Make a voltage and resistance check of the stage (fig. 306).

C. SYMPTOMS:
1. 2,000-yd sweep normal.
2. 32,000-yd sweep entirely absent.
3. Transmitter normal.
4. PPI scope normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Wide gate circuit.	1. Turn up 32,000-yd INTENSITY control R911. If a circular trace does not appear, fault is not in the wide gate circuit.
2. 5-kc amplifier circuit.	2*a.* Replace the 5-kc amplifier tube V605.
	b. Remove plug at J602 and measure the waveform at J602A (output of 5-kc amplifier). Use test oscilloscope amplifier. Connect the horizontal amplifier from pin A to ground and the vertical amplifier from pin B to ground. An elliptical pattern signifies that the 5-kc amplifier stage is operating normally.
	c. Make a voltage and resistance check of the circuit.
3. 32,000-yd sweep circuits, in range indicator unit.	3. Make a voltage and resistance check of the connecting cable to the range indicator, and the range indicator sweep circuit and scope (fig. 142).

D. SYMPTOMS:
1. Sweep on 32,000-yd scope visible only if INTENSITY control R911 is advanced.
2. Sweep on 2,000-yd scope visible only if INTENSITY control R910 on range indicator is advanced.
3. Transmitter inoperative.
4. No PPI sweep.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. 1.7-kc tubes.	1. Replace tubes V604 (1.7-kc multivibrator), and V605 (1.7-kc amplifier) one at a time. Reinsert the original tube in its respective socket if it does not remedy the trouble.

2. 1.7-kc multivibrator.	2*a*. Check waveform at J614 (output of 1.7-kc multivibrator).
	b. Check the voltage and resistance values in the 1.7-kc multivibrator stage.
3. 1.7-kc clipper.	3*a*. Check the waveform at J615 (output of the 1.7-kc clipper). See figure 320**a.**
	b. Make a voltage and resistance check of this stage.

E. SYMPTOMS: 1. 32,000-yd sweep normal.
2. Transmitter operating normally.
3. 2,000-yd sweep not visible unless INTENSITY control R910 is advanced.
4. PPI sweep normal, but no narrow gate marker trace.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Narrow gate tubes.	1. Try replacing V607 (narrow gate delay) and V608 (narrow gate width) tubes one at a time. Reinsert the original tube in its respective socket if it is not found to be defective.
2. Narrow gate delay multivibrator.	2*a*. Check the waveform at J616 (output of narrow gate delay multivibrator). See figure 320**a.**
	b. Make a voltage and resistance check of the circuit.
3. Narrow gate width multivibrator.	3*a*. Check the waveform at J625 (output of the narrow gate width multivibrator).
	b. Make a voltage and resistance check of the stage (fig. 306).

F. SYMPTOMS: 1. 2,000-yd sweep normal.
2. 32,000-yd sweep missing unless the INTENSITY control R908 is turned up.
3. Transmitter normal.
4. PPI scope normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Wide gate tubes.	1. Replace V609 (wide gate delay multivibrator) and V610 (wide gate width multivibrator) tubes one at a time. Reinsert the original tube in its respective socket unless it is found to be defective.
2. Wide gate delay multivibrator.	2*a*. Check the waveform at J617 (output of wide gate delay multivibrator). See figure 320**b.**
	b. Make a voltage and resistance check of the stage.
3. Wide gate width multivibrator.	3*a*. Check the waveform at J624 (output of the wide gate width multivibrator).
	b. Make a resistance and voltage check of the stage and connecting cable and the circuit in the range indicator unit.

G. SYMPTOMS: 1. Echoes on 2,000- and 32,000-yd scopes missing or blurred, but sweeps otherwise normal.
2. Transmitter current zero, abnormally low or fluctuating.
3. PPI sweep missing or otherwise abnormal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Trigger gate tubes.	1. Replace tubes V611 (trigger gate delay), V612 (trigger gate width), and V614 (trigger selector) tubes one at a time. Reinsert the original tube in its respective socket unless defective.
2. Trigger gate delay multivibrator.	2*a*. Check waveform at J618 (trigger gate delay multivibrator). *b*. Make a voltage and resistance check of the stage (fig. 306).
3. Trigger gate width multivibrator.	3*a*. Check waveform at J623 (trigger gate width multivibrator V612 and trigger gate cathode follower V613B). See figure 320**b.** *b*. Make a voltage and resistance check of the stage.
4. Trigger selector.	4*a*. Check waveform at J620 (trigger selector). *b*. Make a voltage and resistance check of the stage.

H. SYMPTOM: Shift in position of the transmitter pulse. (The transmitter pulse normally occurs at about minus 50 yards.)

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Trigger gate delay.	1. Adjust the TRIGGER DELAY control on the front panel of the range unit so as to centralize the trigger pip in the trigger gate. This adjustment is made by connecting a test lead from J623 in the range unit to J911 in the range indicator unit (fig. 320**b**).

I. SYMPTOMS: 1. No indication on either scope screen.
2. Turning the INTENSITY control does not give any indication.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. H-v rectifier in range power supply.	1*a*. Measure bias at J621, range unit (fig. 306). *b*. Make a resistance test. See figure 306. **CAUTION:** The secondary winding of the filament transformer is at –2,000 volts potential and an attempt to measure the filament voltage should never be made until it is ascertained that cable between J910 on the range indicator and cable J804 on the range power

PROBABLE LOCATION OF FAULT	PROCEDURE
	unit have been removed. Connect 115 volt 60-cycle ac to pins S and T on J901.
2. Defective filament transformer T901.	2. Measure the voltage between pins 1 and 14 on V901 or V902. It should be 6.3 volts.

J. SYMPTOMS: 1. No spot on one screen with INTENSITY control set maximum.
2. The other screen is normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Defective scope tube.	1. Replace the tube.

K. SYMPTOM: Spot on the tube but it will not come to a focus.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Defective FOCUS control.	1. Make a resistance test.
2. Improper anode voltage.	2*a*. Measure bias at J621, range unit.
	b. Make a resistance test. Replace any defective parts.

L. SYMPTOM: Range hairlines do not move when TRACKING handwheel is rotated.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Aided tracking rectifier.	1*a*. Replace V929.
	b. Make a voltage-resistance check of the aided tracking rectifier circuit (figs. 112 and 319).
2. Relay K2101.	2. Check continuity at relay K2101 (fig. 143).
3. Range servo drive.	3*a*. Check V926, V927, and V928 one at a time by replacing.
	b. Make a voltage resistance check of these stages (figs. 113 and 319).
4. Field supply for B901 and B902.	4*a*. Replace V801 in range power supply.
	b. Make a voltage resistance check (figs. 139 and 307).

266. RANGE SYSTEM, TROUBLE-SHOOTING CHART—N^2 GATE OR ART OPERATION.

A. SYMPTOM: No illuminating of N^2 gate on the 2,000- or 32,000-yd scope.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Input multivibrator V2110.	1*a*. Check for output with test oscilloscope at jack J2112. If normal see next fault.
	b. Check tubes V2110 and V2111 by replacing.
	c. Make a voltage and resistance check of these stages (fig. 312).
2. Delay saw-tooth generator, differentiator and amplifier, or illuminating gate generator.	2*a*. Check for output with test oscilloscope at jack J2115. If an output appears, check cabling to range indicator unit.
	b. Replace tubes V2101, V2112, V2106, and V2113 one at a time.
	c. Make a voltage and resistance check of these stages.

B. SYMPTOM: No N^2 gate on 2,000-yd scope.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Marker intensity circuit.	1*a*. Check for correct waveform at jack J2116. If normal check cable from jacks J2111 to J913 on range indicator. *b*. Make a voltage and resistance check on R2181 the MARKER INTENSITY control.
2. N^2 gate generator.	2*a*. Replace tubes V2111 and V2107, one at a time. *b*. Make a voltage and resistance check on the stage.

C. SYMPTOMS: 1. Target not followed in range with RANGE TRACKING switch on AUTOMATIC.
2. Tracking normal when switch is on MANUAL.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Relay circuit of K2102.	1*a*. Check action of relay K2102 by throwing the RANGE TRACKING switch to AUTOMATIC. *b*. If no action, check cabling from jacks J2102 to J1758 on indicator-control panel.
2. Video peaker and splitter.	2*a*. Replace tubes V2108 and V2109. *b*. Make a voltage and resistance check on these stages (fig. 312).

D. SYMPTOM: N^2 gate does not lock on target when RANGE TRACKING switch is thrown to AUTOMATIC.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. BIAS GATE potentiometer.	1. Make a voltage and resistance check of R2184.
2. N^2 gate tracker and storage network.	2*a*. Replace tubes V2102, V2103, and V2114, one at a time. *b*. Make a voltage and resistance check of these stages.

E. SYMPTOMS: 1. Range hairlines do not move with N^2 gate on automatic range tracking.
2. N^2 gate follows video signal on manual range tracking.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Servo tracker or d-c amplifiers.	1*a*. Replace tubes V2115, V2116, and V2117, one at a time. *b*. Check that the coast relay K2103 is not stuck. *c*. Check continuity of contacts of relay K2101. *d*. Make a voltage and resistance check of these stages.

F. SYMPTOM: N^2 gate remains stationary with RANGE TRACKING switch in either position.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Oscillator phase shifter unit.	1a. Remove tube V2104 and check for 410-kc sine wave with test scope at pin 4. If there is an output see next fault. If no output, check for negative gate at grid (pin 4) of V954.
	b. If no output at grid of V954, replace V954 and make a voltage and resistance check of the stage.
	c. Check cable from jacks J2107 to J951 in range indicator unit.
	d. If output is obtained at V954, check V952 and phase shifting capacitor and V953.
	e. Make a voltage and resistance check on these stages.
2. Sine wave amplifiers.	2a. Replace tubes V2104 and V2105.
	b. Make a voltage and resistance check on these stages.

SECTION II
ALIGNMENT

267. GENERAL.

a. Before attempting to line up the range system, the power switches on the range power unit and on the auto range power unit should be turned on, the system should be allowed to warm up for several minutes, and the three ART-NORMAL switches set to the NORMAL position. The regulated output voltages of the two power units should be checked. The control on the range power unit should be set so that the voltage at test jack J619 on the range unit is 250 volts. The control on the auto range power supply should be set so that the voltage at pin C on the power cable to jack J2105 or at pin 5 of V2101 is 250 volts.

b. To view the test waveforms on the range indicators during the alignment procedure, set the NARROW GATE WIDTH and the WIDE GATE WIDTH controls to the full counterclockwise position (zero width). Turn up the INTENSITY controls and FOCUS controls on both scopes until the traces on the two scopes are visible. Connect test cable W2118 to the monitor jack J911.

268. RANGE UNIT, 81.95-KC OSCILLATOR.

a. Adjust the 2,000-yard CENTERING controls R628 and R629, the oscillator tuning and phase capacitors C621 and C627, and the BALANCE resistor R621 to obtain a circular pattern on the 2,000-yard scope V901.

b. Adjust the 2,000-yard sweep diameter to 2 inches by means of the 2,000-yard sweep DIAMETER control, potentiometer R698. The diameter of the circle increases with a clockwise rotation of R698. It should be possible to increase the diameter to 2.5 inches by means of control R698.

c. Switch the crystal SELECTOR switch S601 several times to test the operation of both crystals and the reliability of crystal starting.

269. RANGE UNIT, 20-KC MULTIVIBRATOR.

a. Connect the output of the 20-kc multivibrator J612 to the range indicator unit with special test cable W2118.

b. When the 20-KC MV control C606 is properly adjusted, a pattern similar to figure 320**a** is obtained on the 2,000-yd scope. A stationary pattern is obtained over a fairly wide range. Note the limits of this range and set the 20-KC MV control in the approximate center.

270. RANGE UNIT, 5-KC MULTIVIBRATOR.

a. With the test lead still in test jack J612, adjust the 5-kc multivibrator control until a single trace similar to that shown in figure 320**a** appears on the 32,000-yard scope. This trace may not be circular because of faulty adjustment of the 32,000-yard sweep controls.

b. Connect the output of the 5-kc multivibrator at J613 to the range unit with test cable W2118. A stationary pattern similar to figure 320**a** should be obtained on the 32,000-yard scope.

271. ADJUSTMENT OF THE CIRCULAR SWEEPS.

The 2,000-yard and the 32,000-yard sweep controls on the front panel of the range unit labeled DIAMETER, PHASE, BALANCE, and CENTERING should be adjusted so as to obtain a well-centered circular trace. When the sweeps are circular and centered, the range data from the calibrated scales around the scopes will be correct; so no calibration of the range unit is required. However, the sweeps must be kept circular and centered. Normally, the range of the panel controls are sufficient to keep the sweeps properly aligned. If it should become impossible to align the sweeps with these controls, the procedure outlined in the following paragraphs have to be followed.

272. ADJUSTMENT OF THE 32,000-YARD CIRCULAR SWEEP.

a. Remove the cable from J602 and connect a test lead from J602B to the vertical input of the test oscilloscope. Use an analyzer lead, inserting the pin plug of the analyzer lead into J602B and taking care not to force the plug all the way in. Adjust the oscilloscope controls to produce a vertical line about 2 inches long.

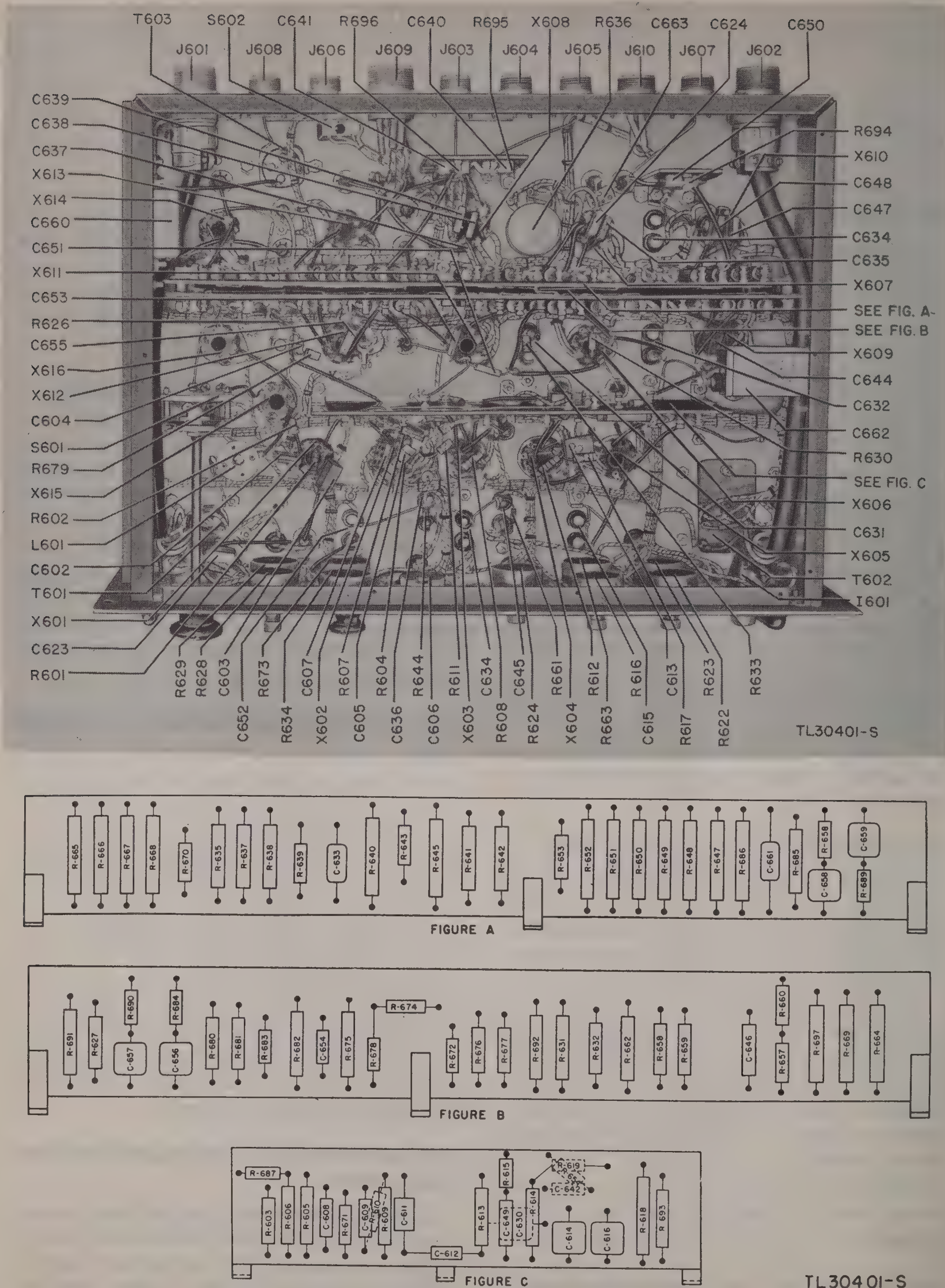


Figure 305. Range unit, bottom view, parts identified.

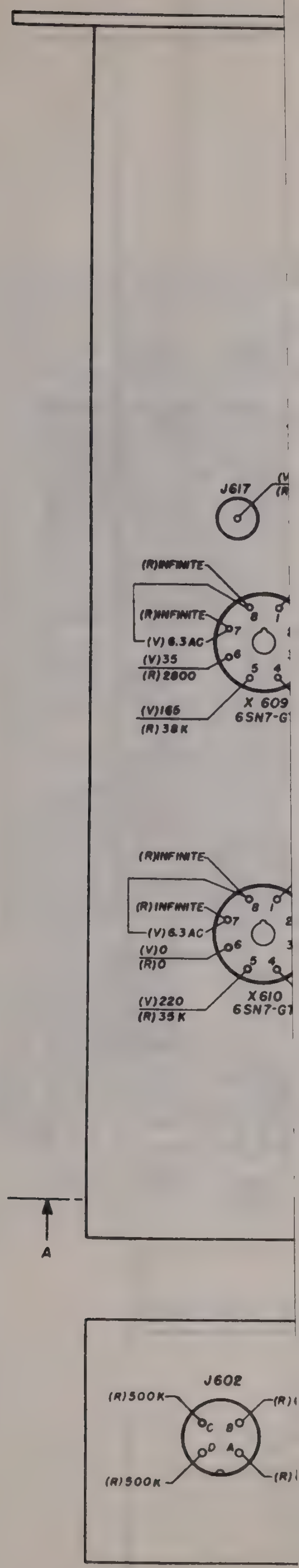
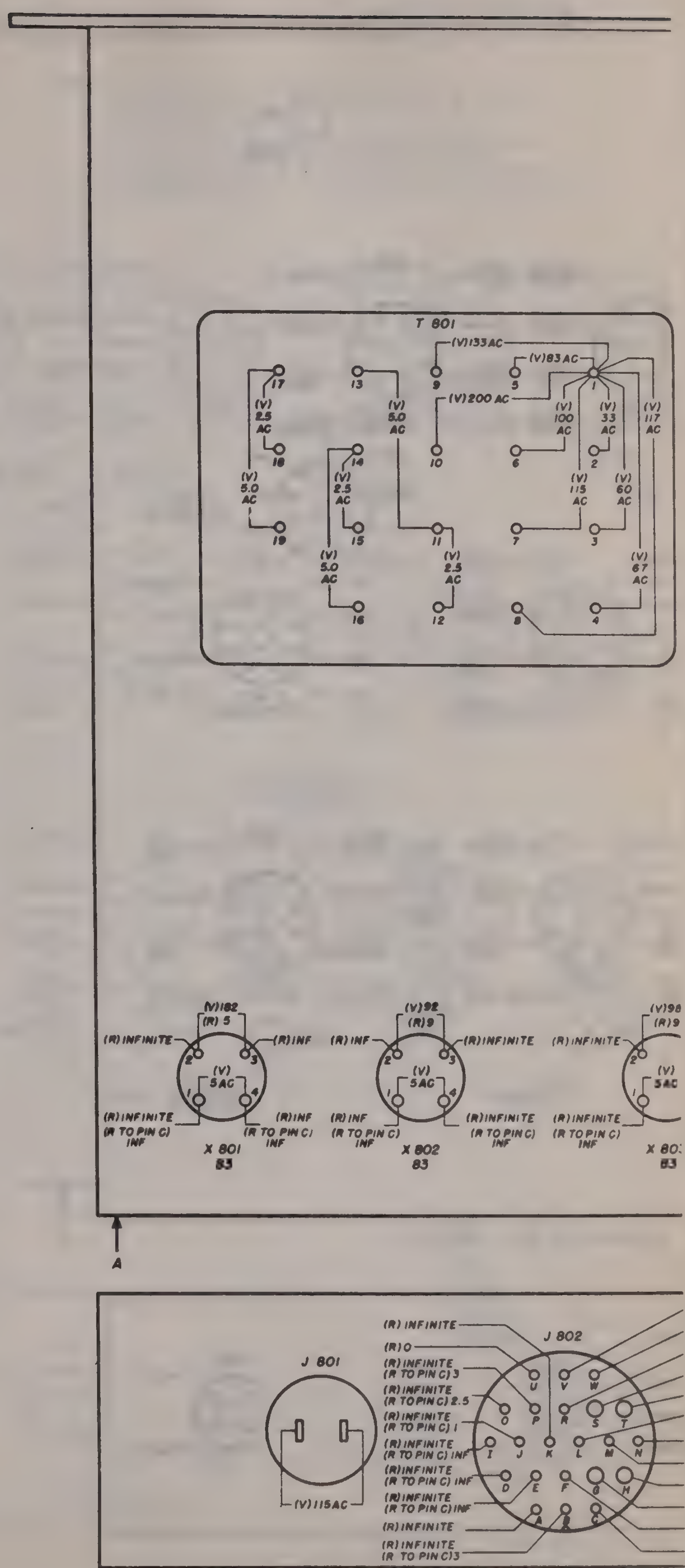


Figure 307. Range power unit, voltage and resistance chart.



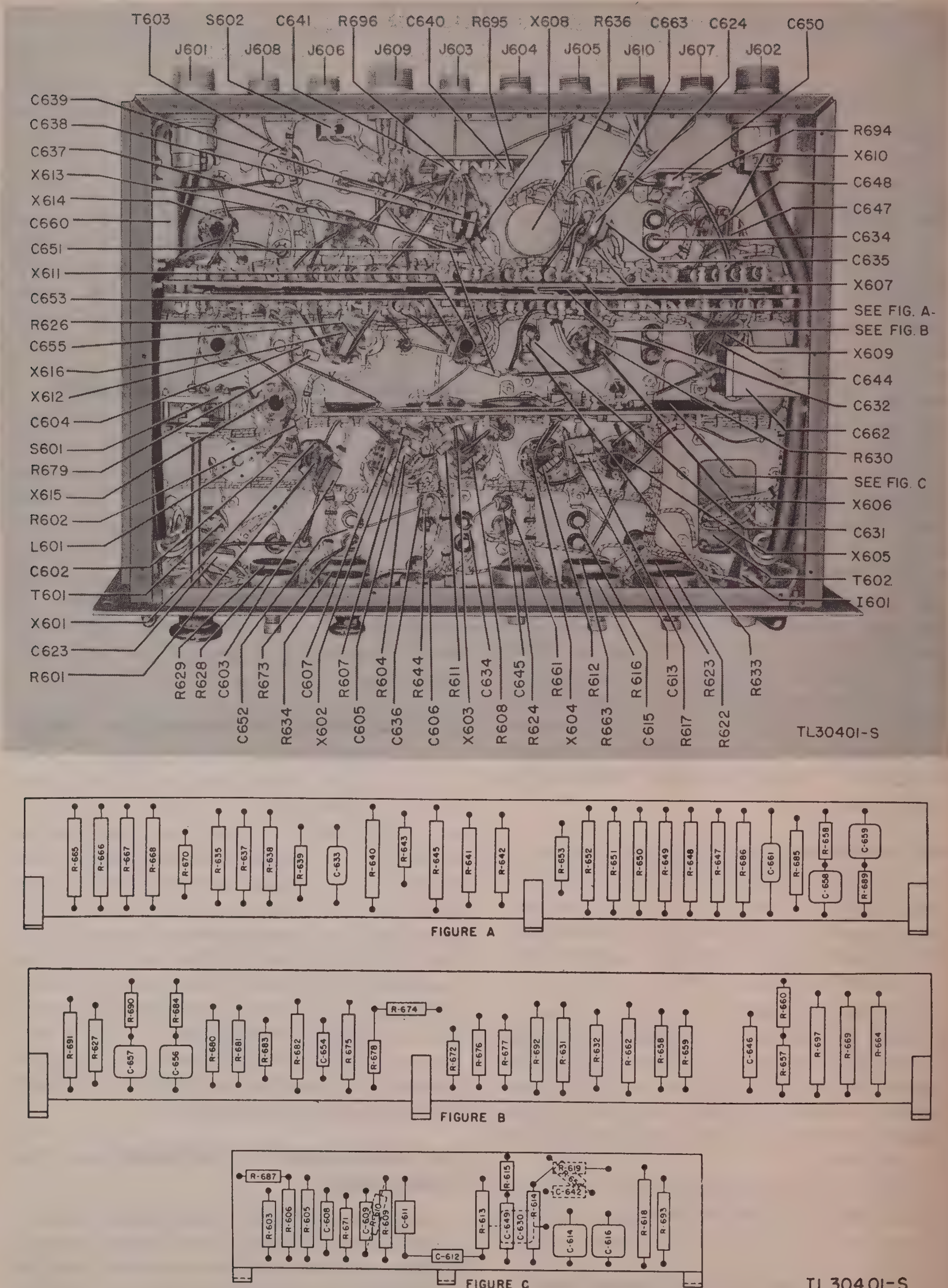


Figure 305. Range unit, bottom view, parts identified.

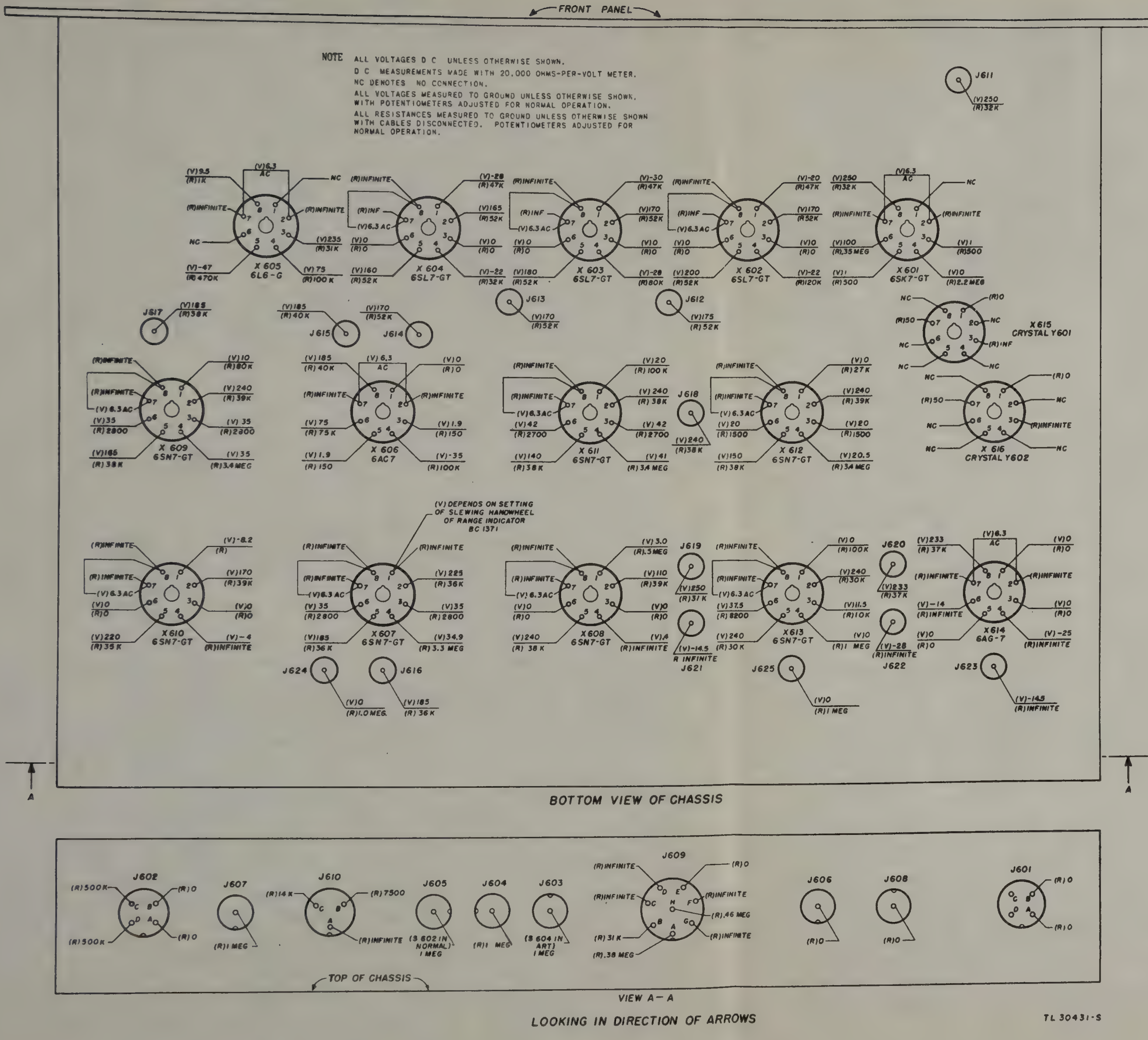


Figure 306. Range unit, voltage and resistance chart.

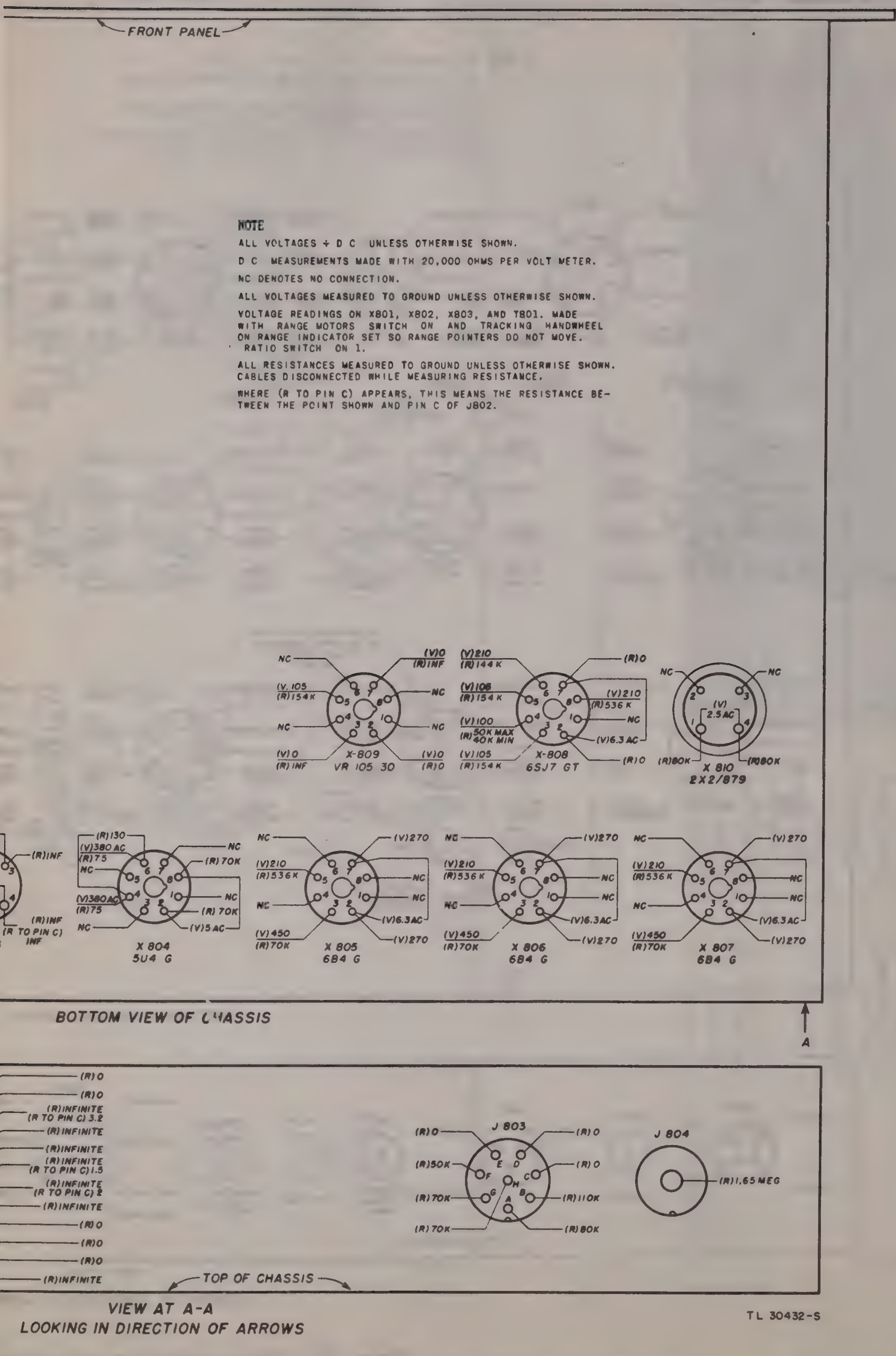


Figure 307. Range power unit, voltage and resistance chart.

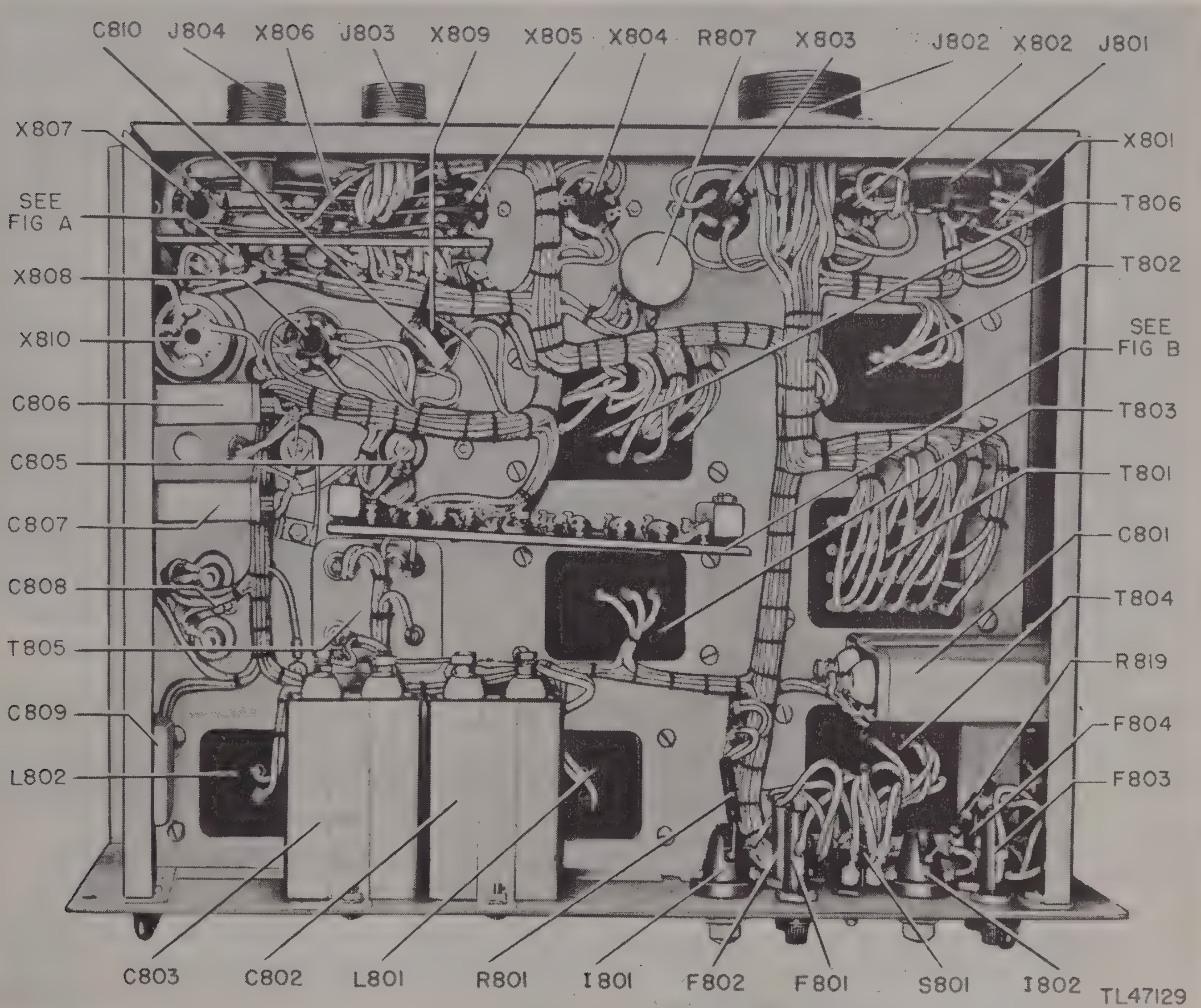


Figure 308. Range power unit, bottom view, parts identified.

Figure 307. Range power unit, voltage and resistance chart.

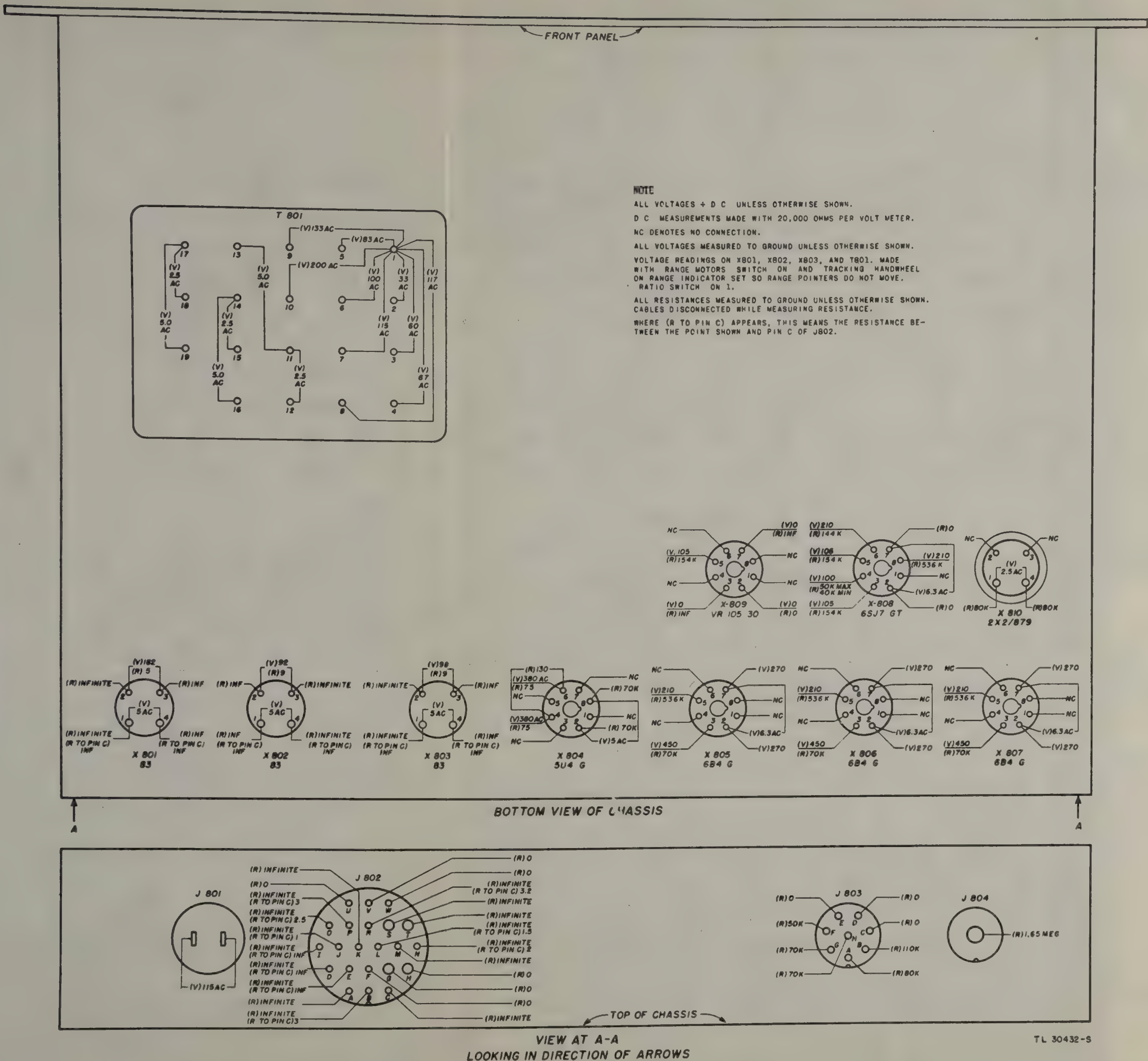


Figure 307. Range power unit, voltage and resistance chart.

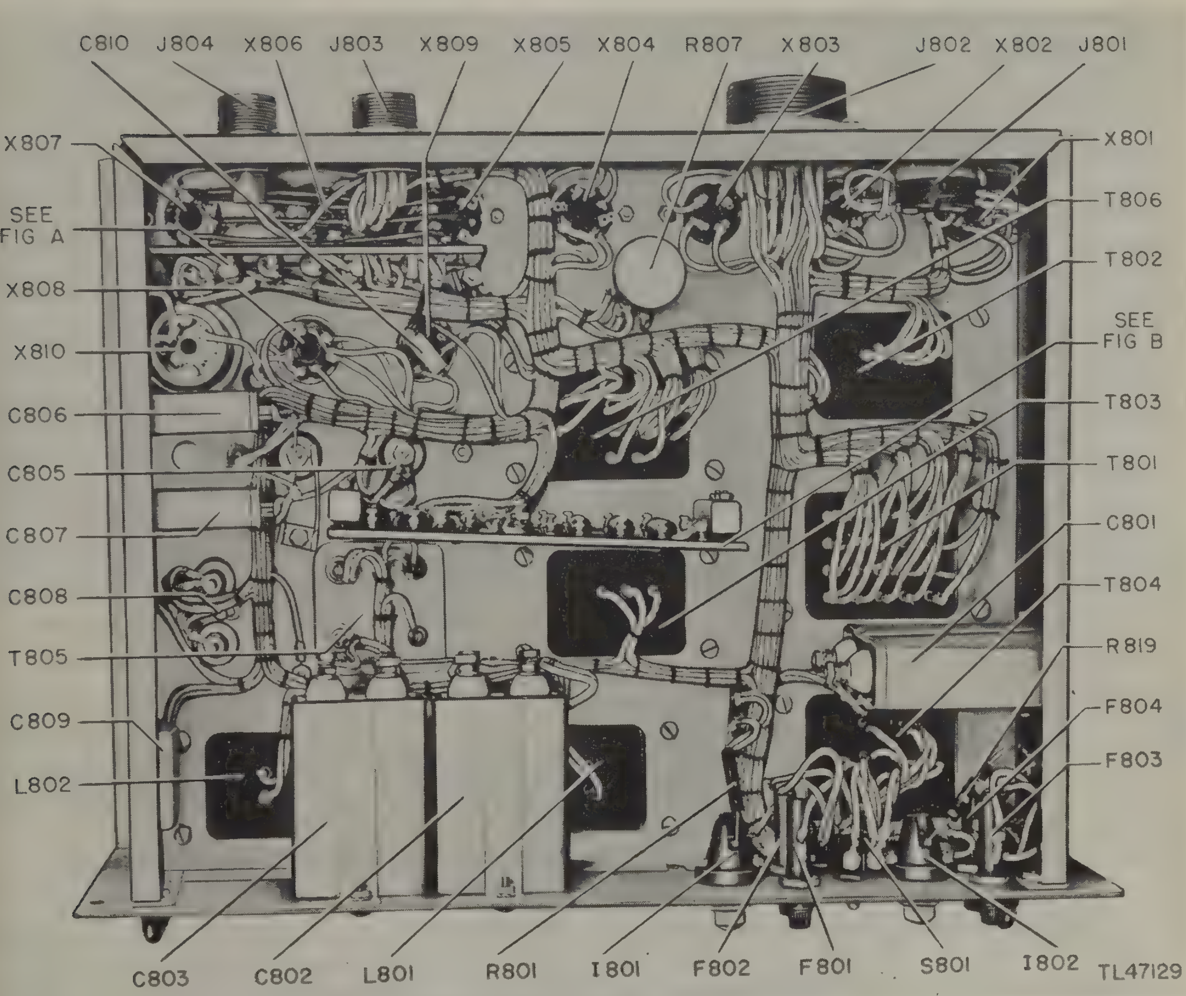


Figure 308. Range power unit, bottom view, parts identified.

b. Adjust the 32,000-yard BALANCE control R625 for maximum deflection on the test scope.

c. Tune the primary slug of transformer T602 for maximum deflection on the test scope.

d. Adjust the 32,000-yard PHASE control C620 so that it is in the middle of its range, with the slot horizontal.

e. Tune the secondary slug of transformer T602 for maximum deflection on the test scope. If the length of line is greatest when the slug is at one extremity of its adjustment, remove the bottom cover from the range unit to make accessible the two additional tuning slugs at the bottom of the secondary winding.

f. Replace the cable connection between J602 and J908.

g. Short circuit terminal 2 on transformer T904 to ground. A straight line is obtained on the 32,000-yard scope. Adjust the tuning slug of transformer T905 for maximum deflection.

h. Remove the short circuit from transformer T904 and connect a lead from terminal 2 of transformer T905 to ground. A straight line obtained on the 32,000-yard scope is at right angles to the straight line obtained in the preceding step. Adjust the tuning slug of transformer T904 for maximum deflection. Remove the short circuit from terminal 2.

i. Set the 32,000-yard DIAMETER control R699 so that the trace lies between the two circles scribed on the disk over the face of the tube.

j. Adjust the 32,000-yard BALANCE control R625 so that the trace is as nearly circular as possible.

k. Adjust the two 32,000-yard CENTERING controls R622 and R623 to center the circular trace.

l. Adjust the 32,000-yard PHASE control to further improve the circularity of the trace.

m. Repeat adjustments **j**, **k**, and **l** since there is some interaction between the several adjustments.

273. ADJUSTMENT OF THE 2,000-YARD CIRCULAR SWEEP.

a. Remove the cable from J601 and connect a test lead from J601B to the vertical input of the test oscilloscope. Adjust the oscilloscope controls to produce a vertical line about 2.5 inches long.

b. Adjust the 2,000-yard BALANCE control R621 for maximum deflection on the test scope.

c. Adjust the OSCILLATOR TUNING control C621 for maximum deflection. This tunes the primary winding of T601 to resonance.

d. Adjust the 2,000-yard SWEEP PHASE control C627 for maximum deflection. This tunes the secondary winding of T601 to resonance.

e. Replace the cable connecting J601 to J908.

f. Short circuit terminal 2 on transformer T903 to ground. A straight line is obtained on the 2,000-yard scope. Adjust the tuning slug of transformer T902 for maximum deflection. Remove the short circuit.

g. Short circuit terminal 2 of transformer T902 to ground. A straight line will be obtained on the 2,000-yard scope at right angles to the straight line obtained in the preceding step. Adjust the tuning slug of transformer T903 for maximum deflection.

h. Set the 2,000-yard DIAMETER control so that the trace lies between the two circles scribed on the face of the disk in front of the scope.

i. Adjust the 2,000-yard BALANCE control so that the trace is as nearly circular as possible.

j. Adjust the two CENTER ADJUST controls to make the circular trace concentric with the scribed circles.

k. Adjust the 2,000-yard PHASE control to further improve the circularity of the trace.

l. Repeat adjustments **h**, **i**, **j**, and **k** to produce the best sweep. The adjustments must be made carefully as the accuracy of the range data is dependent upon the circularity and proper centering of the sweep.

274. ADJUSTMENT OF TRIGGER DELAY CONTROL.

a. Connect the test cable from test jack J620 to jack J911 of the range indicator.

b. Adjust the TRIGGER DELAY control on the range unit starting from the full counterclockwise position until the second trigger pip appears on the range scopes.

c. Connect the test cable to test jack J623 on the range unit. The positive trigger gate pulse will cause an inward deflection to be observed on the range scopes. At the bottom of the pulse there is a small indentation because of the trigger generator pip. This indentation occurs because the screen of the trigger generator draws current when the trigger pip is applied to its grid. The TRIGGER DELAY control should be set so that this small indentation is centralized within the trigger gate pulse.

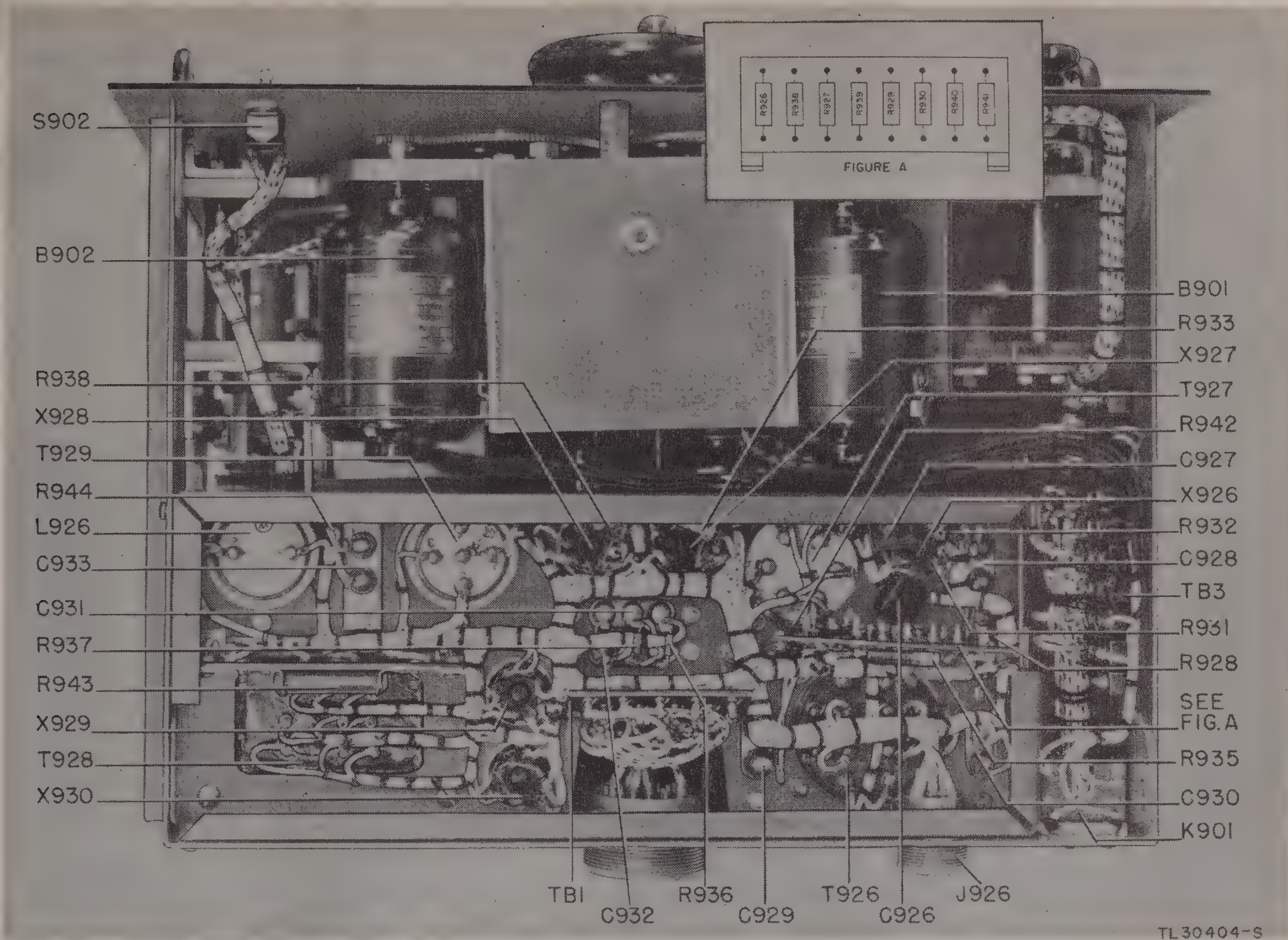


Figure 309. Range indicator, bottom view, parts identified.

275. ADJUSTMENT OF WIDE AND NARROW GATE WIDTH CONTROLS.

a. Reduce the setting of the INTENSITY controls of the two range indicator scopes until the sweep lines just disappear.

b. Adjust the setting of the NARROW GATE WIDTH control to produce a circular arc one quarter of a circle (500 yards) on the 2,000-yard scope.

c. Adjust the setting of the 2,000-yard INTENSITY and FOCUS controls to produce a sharp clear sweep line.

d. Adjust the setting of the WIDE GATE WIDTH control until the sweep line on the 32,000-yard scope just makes a complete circle, but does not close upon itself.

e. Adjust the setting of the 32,000-yard INTENSITY and FOCUS controls until a sharp sweep line results. It may be necessary to readjust the 2,000-yard FOCUS and INTENSITY controls.

276. ADJUSTMENT OF WIDE AND NARROW GATE DELAY CONTROLS.

a. Plug the test cable into jack J620. A trigger pulse should appear on the 32,000-yard scope.

b. Adjust the WIDE GATE DELAY control until the sweep line starts at the base of the trigger pulse on the coarse range scope.

c. Turn the range handwheel until the coarse and fine range dials read zero.

d. Set the NARROW GATE DELAY control so that the trigger pulse is visible on the brightened part of the 2,000-yard sweep.

277. RANGE ZERO ADJUSTMENT.

Each receiver, range unit, and range indicator has delay characteristics that cause the received signal to be delayed more than the transmitted pulse. Before each radar set leaves the factory, the receiver, range unit, and range indicator are calibrated to determine the correct negative range reading for the transmitted pulse to compensate for the unequal delay. Each time one of

these components is replaced, a new calibration chart should be made. To determine the new range zero setting, it is necessary to have a fixed target at a known range from the radar set. This range should be known within approximately one yard. The range hairlines should be set at the exact range of the target, and the scope tubes rotated until the leading (counterclockwise) edge of the target echo starts to break away from the circular base line just under the range hairlines. The receiver AGC switch should be on and the local oscillator tuned carefully for this adjustment. The new range zero setting is determined by turning the range hairlines to the break-away of the transmitted pulse and reading the range indicated. This range will be between –25 yards and –50 yards in most cases.

a. Turn on the transmitter and carefully tune the local oscillator. The receiver AGC switch should be turned to the ON position.

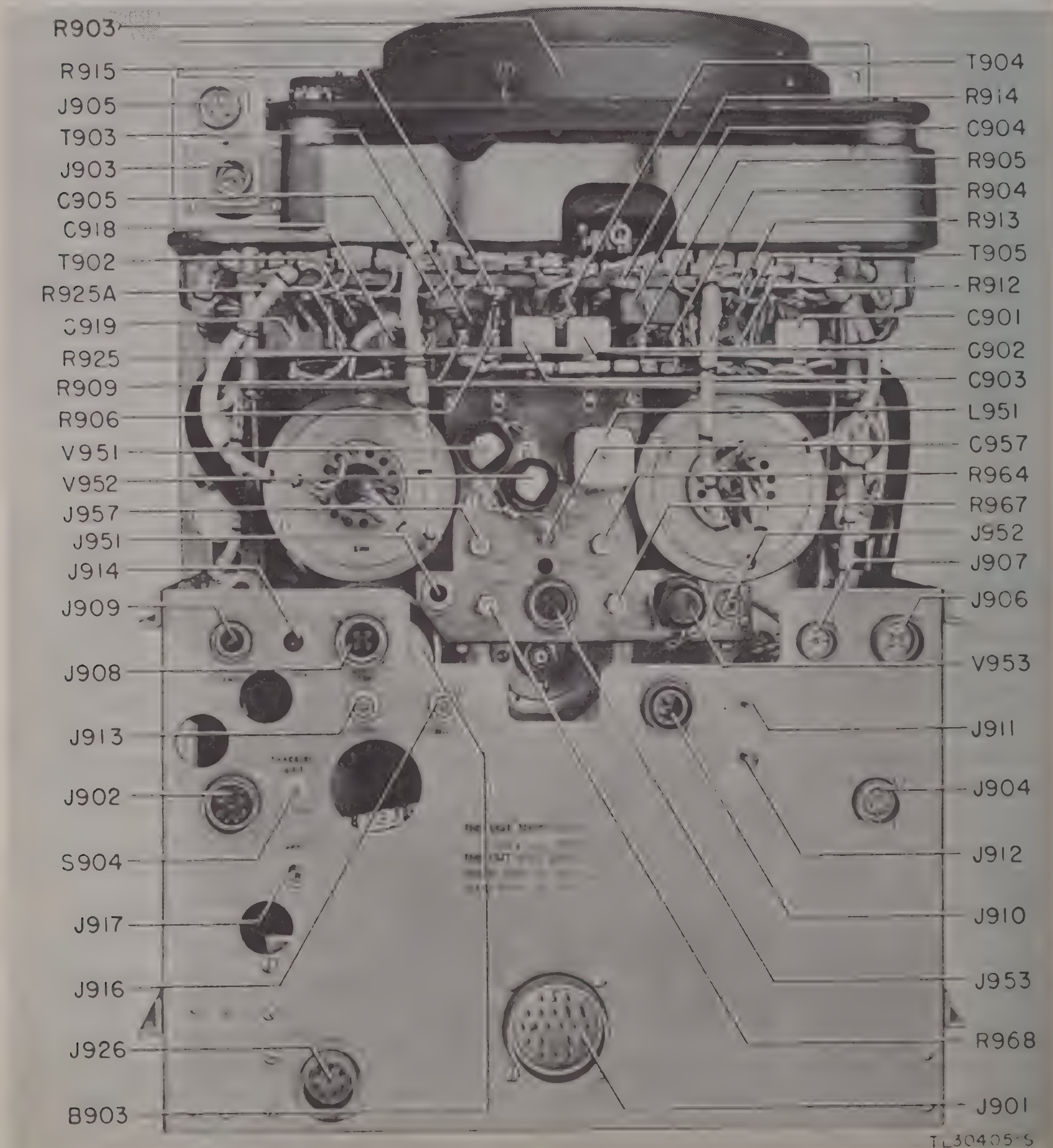


Figure 310. Range indicator, rear view, parts identified.

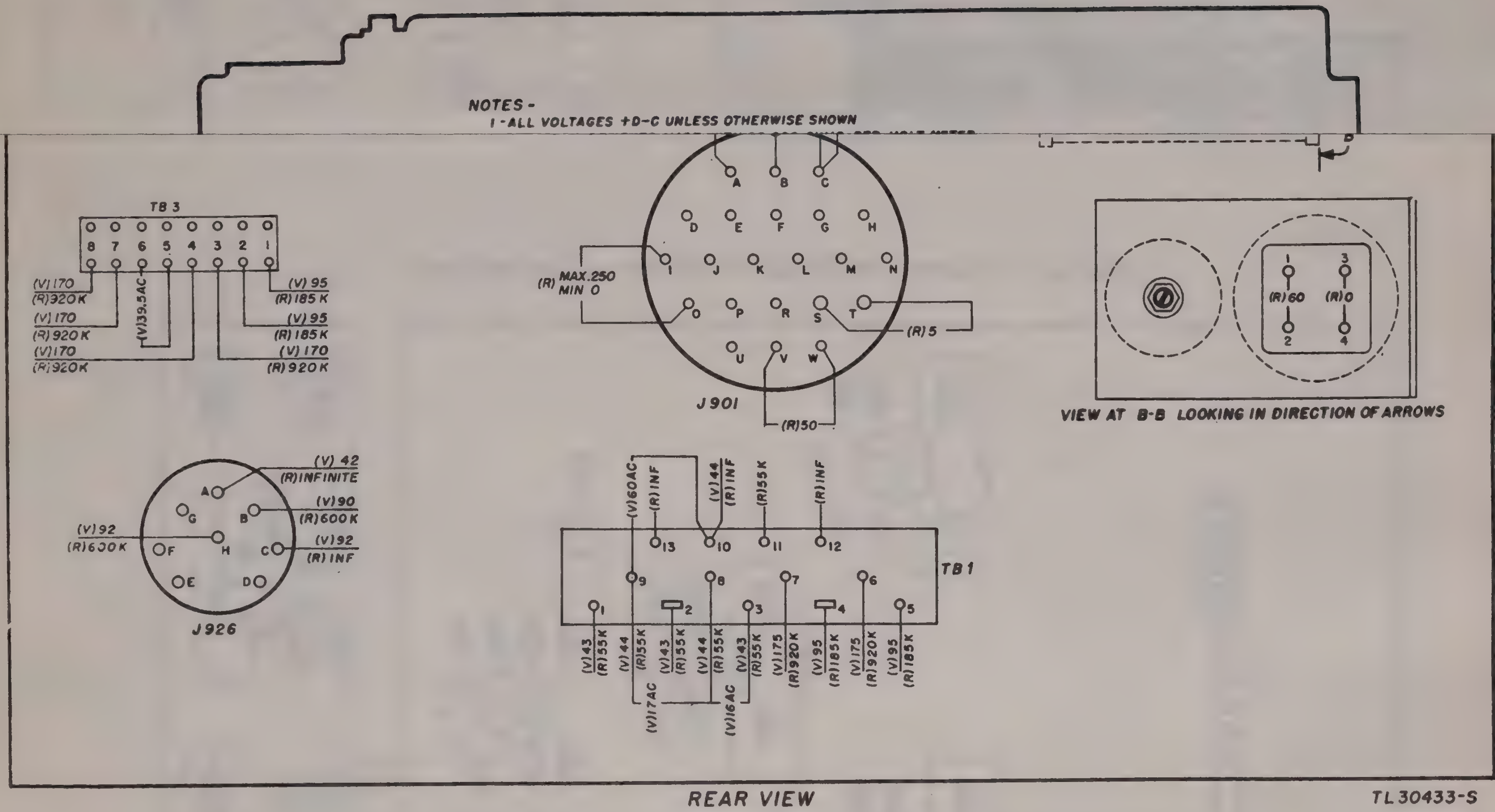


Figure 311. Range indicator, voltage and resistance chart.

these components is replaced, a new calibration chart should be made. To determine the new range zero setting, it is necessary to have a fixed target at a known range from the radar set. This range should be known within approximately one yard. The range hairlines should be set at the exact range of the target, and the scope tubes rotated until the leading (counterclockwise) edge of the target echo starts to break away from the circular base line just under the range hairlines. The receiver AGC switch should be on and the local oscillator tuned carefully for this adjustment. The new range zero setting is determined by turning the range hairlines to the break-away of the transmitted pulse and reading the range indicated. This range will be between –25 yards and –50 yards in most cases.

a. Turn on the transmitter and carefully tune the local oscillator. The receiver AGC switch should be turned to the ON position.

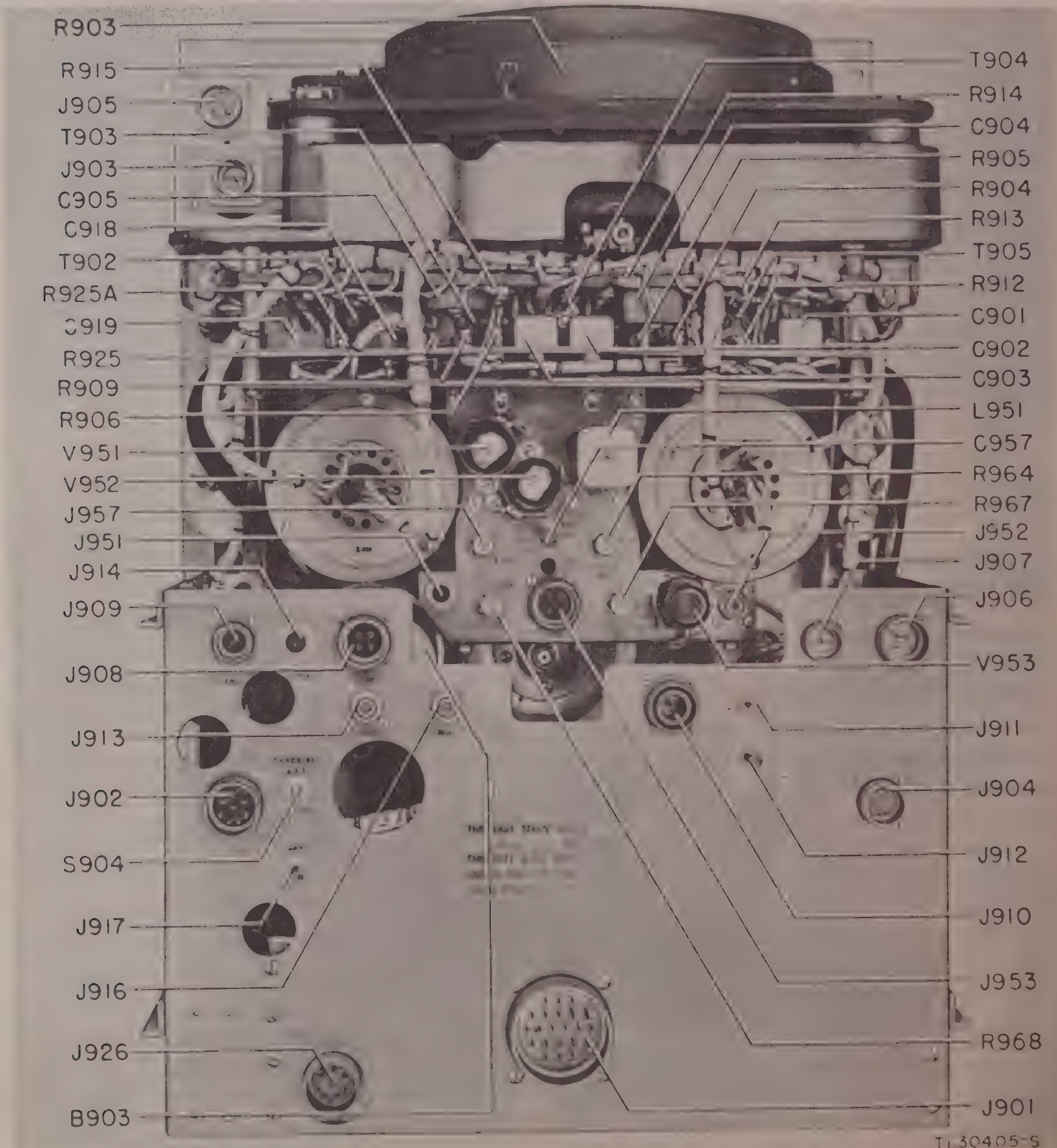


Figure 310. Range indicator, rear view, parts identified.

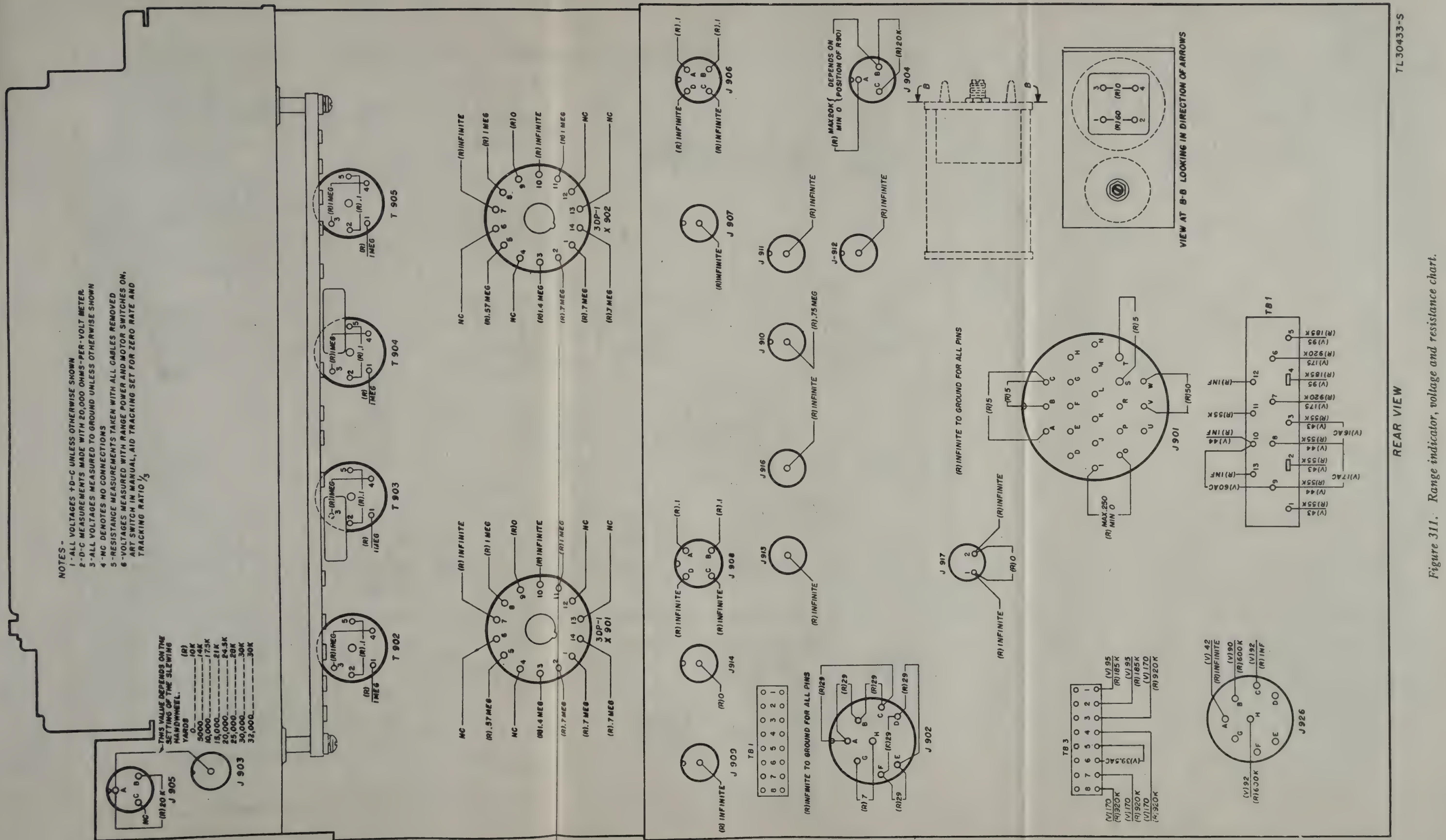


Figure 311. Range indicator, voltage and resistance chart.

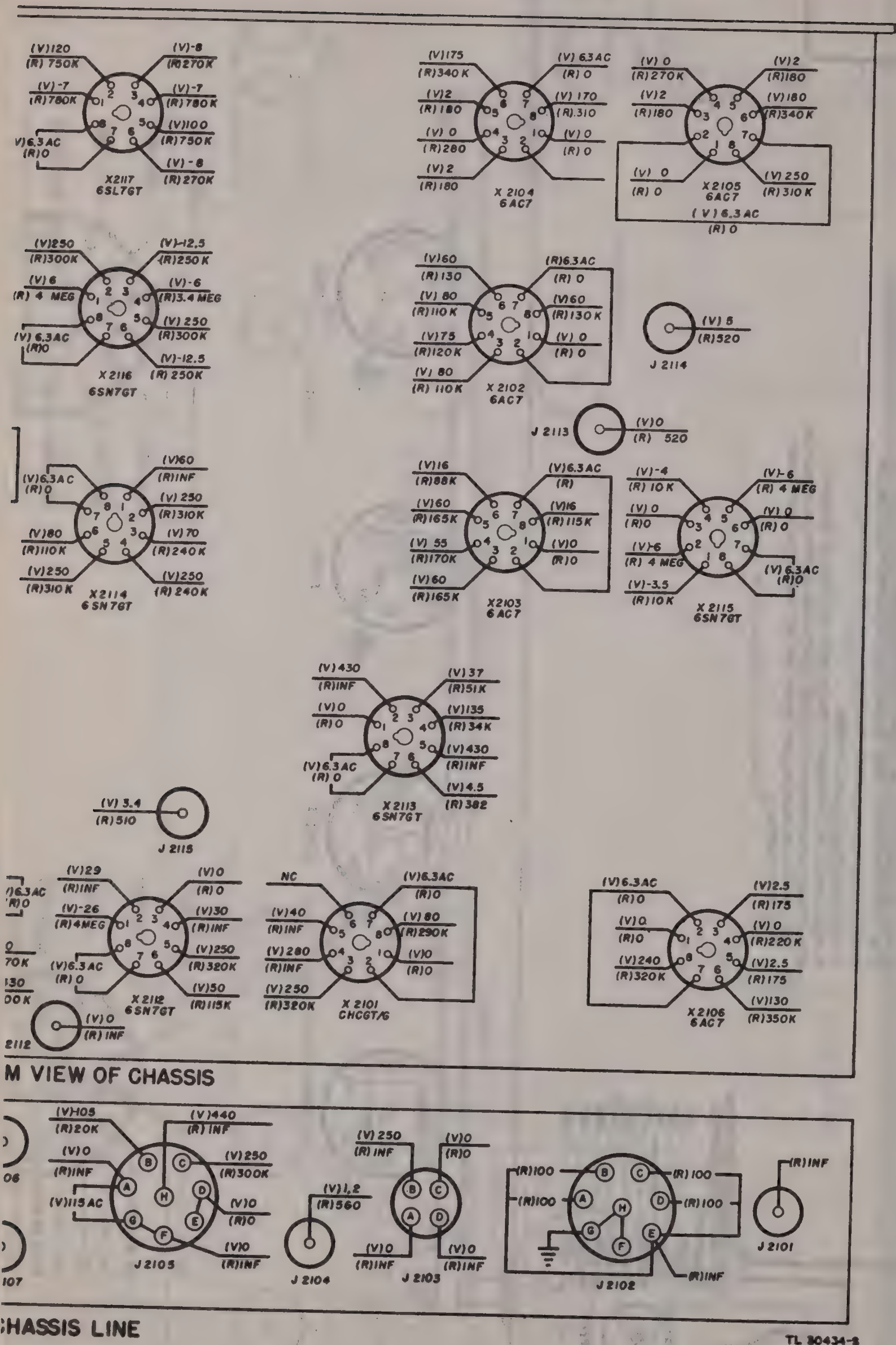


Figure 312. Automatic range tracking unit, voltage and resistance chart.

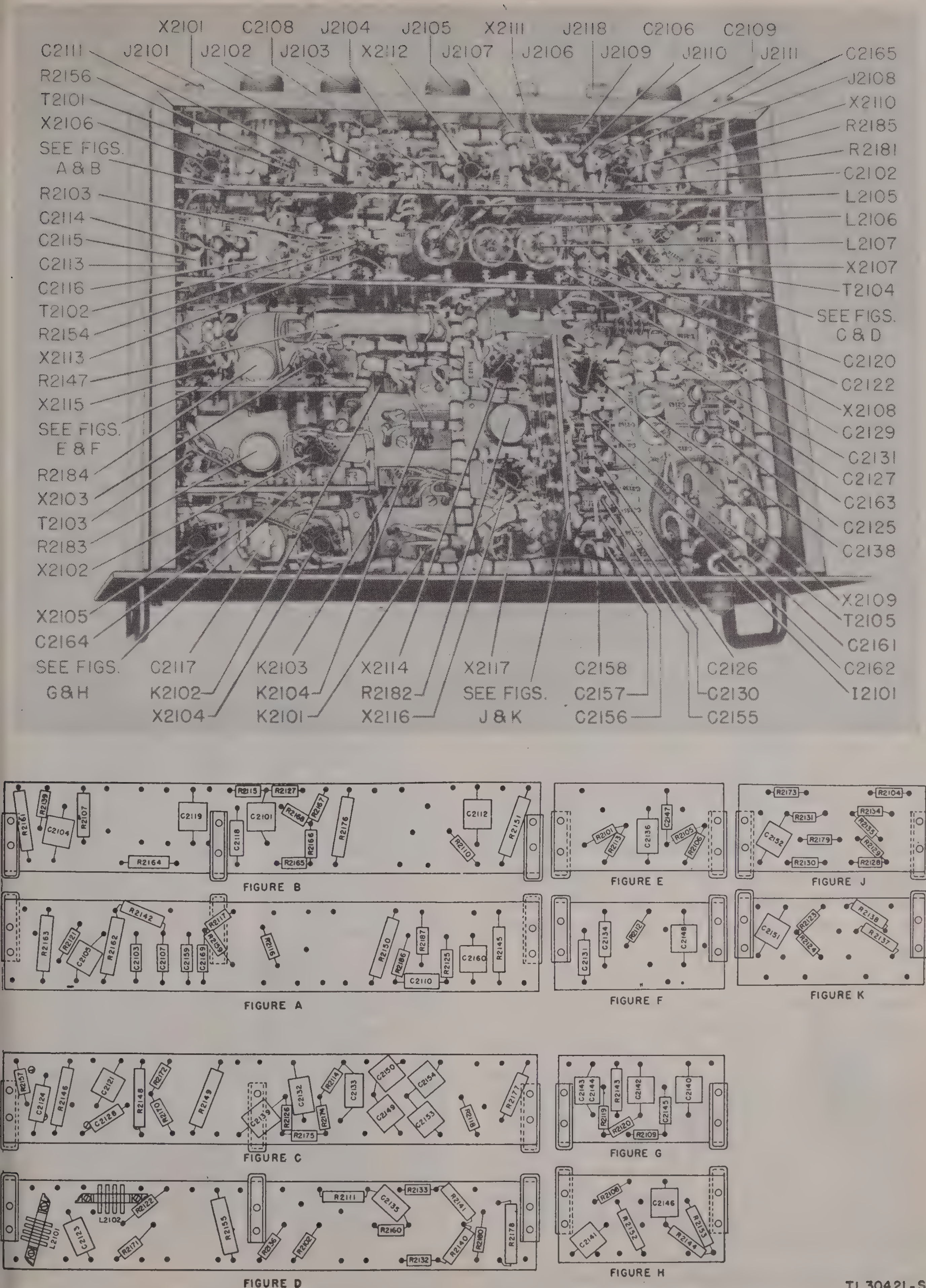


Figure 313. Automatic range tracking unit, bottom view, parts identified.

Figure 312. Automatic range tracking unit, voltage and resistance chart.

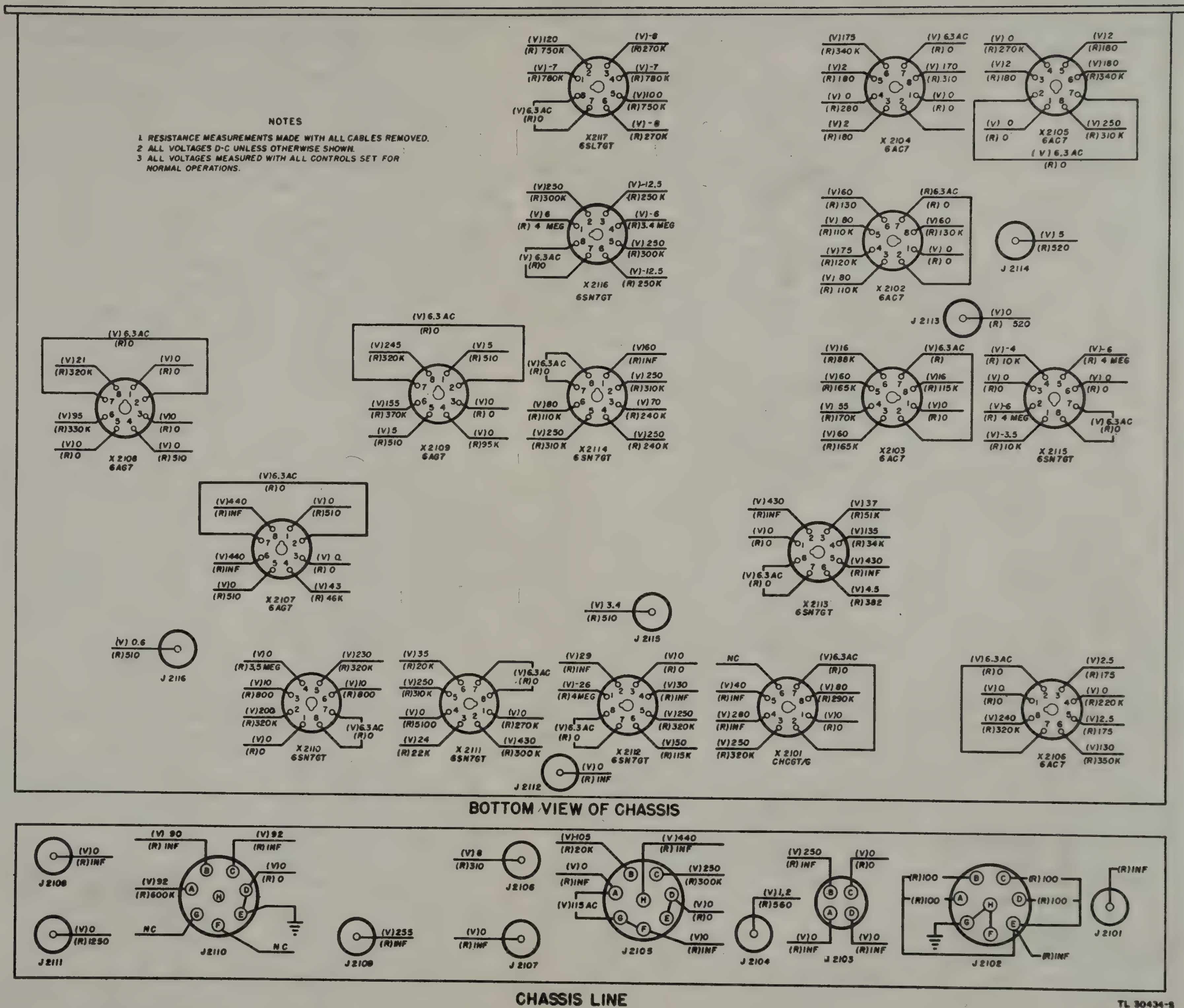


Figure 312. Automatic range tracking unit, voltage and resistance chart.

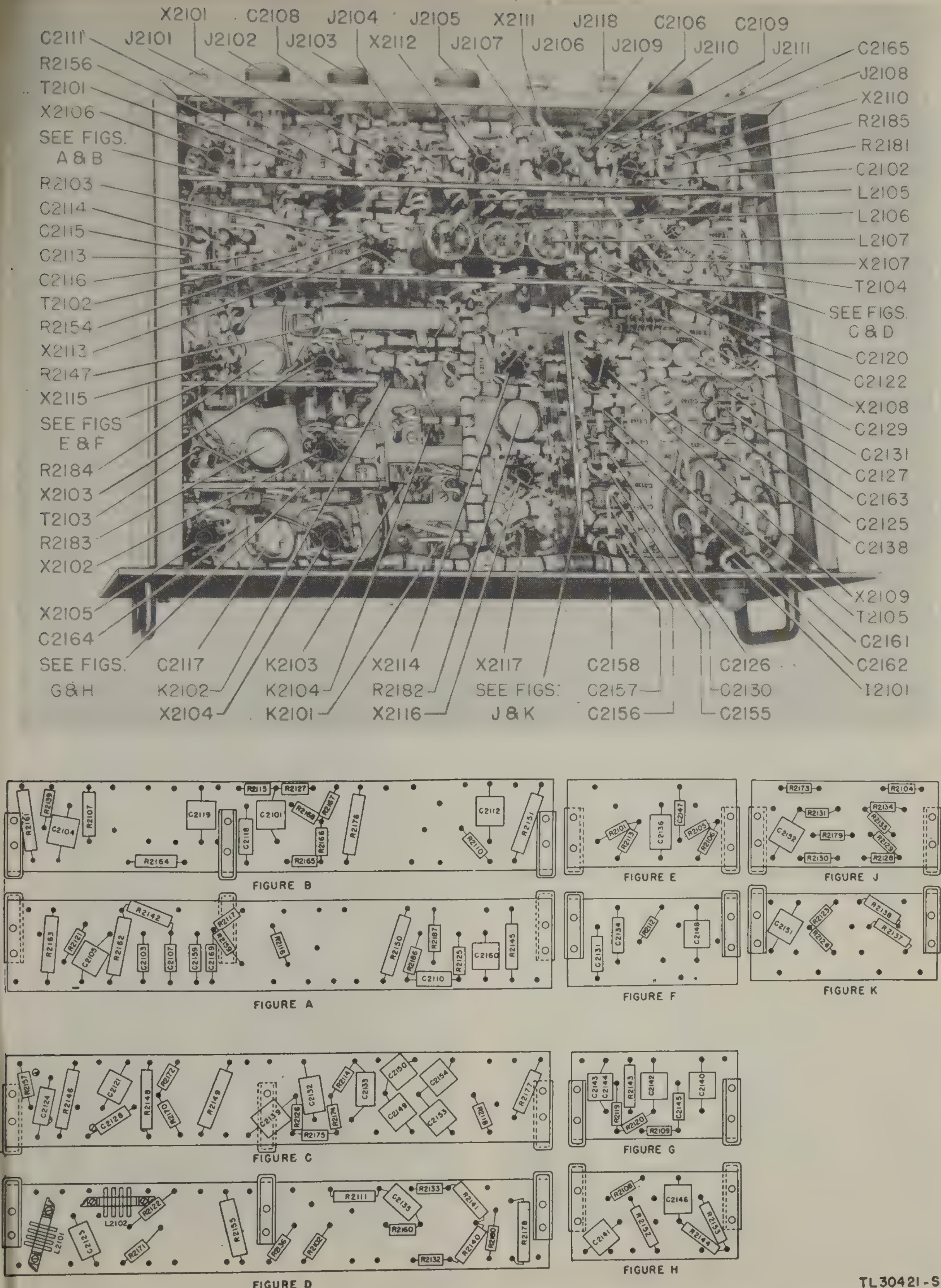


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Figure 313. Automatic range tracking unit, bottom view, parts identified.

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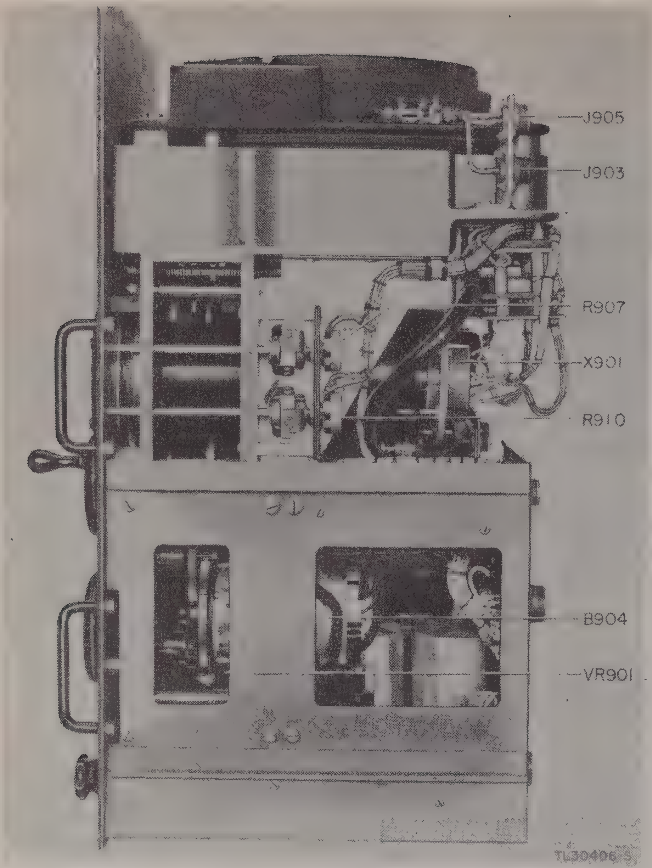

Figure 314. Range indicator, right side, parts identified.

b. Set the range hairlines to the range indicated on the calibration card on the range indicator.

c. Loosen the three orienting screws at the rear of the range scopes and orient the tubes until the leading (counterclockwise) edge of the transmitted pulse, where it breaks away from the sweep line, is under the range hairlines.

278. NARROW GATE TRACKING ADJUSTMENT.

a. Turn the range handwheels to zero range.

b. Set the switch on the back of the range indicator to the NORMAL position.

c. Set the NARROW GATE DELAY control so that the 2,000-yard sweep line is brightened under the range hairline.

d. Turn the range handwheels slowly toward the 32,000-yard scope. If during this process the narrow gate tends to lead or lag the range hairlines on the 2,000-yard scope, adjust the NARROW GATE control so that the gate and hairline stay together. Each time the NARROW GATE control is changed the hairline should be reset to zero and the NARROW GATE DELAY control should be reset.

279. N² GATE TRACKING ADJUSTMENT.

a. Maximum Range Set. Adjust the input multivibrator so that its output is a symmetrical square wave. This is done by connecting the test oscilloscope to test jack J2112 and adjusting the MAXIMUM RANGE ADJUST control to make the waveform, viewed at that test point, a symmetrical square wave which gives a maximum range of approximately 48,000 yards.

b. 410-kc Frequency Adjust.

(*1*) Throw the RANGE CALIBRATE switch on the control panel to the CALIBRATE position, turn the range slewing handwheel until the hairline on the two scopes covers the bright N² gate spot on the scopes, and return the RANGE CALIBRATE switch to the OFF position. The spot may or may not move when the switch is returned to normal.

(*2*) Set the 410-kc frequency by observing the relative position of the bright spot with respect to the hairline on the 2,000-yard scope. When the 410-KC FREQUENCY ADJUST is properly set, the position of the spot with respect to the hairline will not change as the slewing handwheel is turned throughout its entire range. A rough indication of the oscillator frequency can be obtained by connecting test cable W2118 between the range indicator jack J911

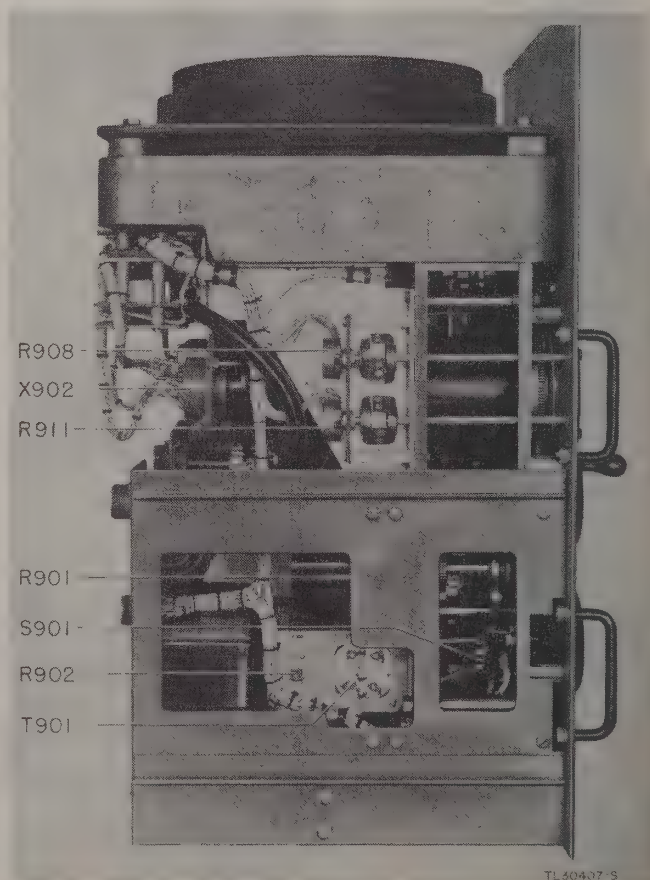

Figure 315. Range indicator, left side, parts identified.

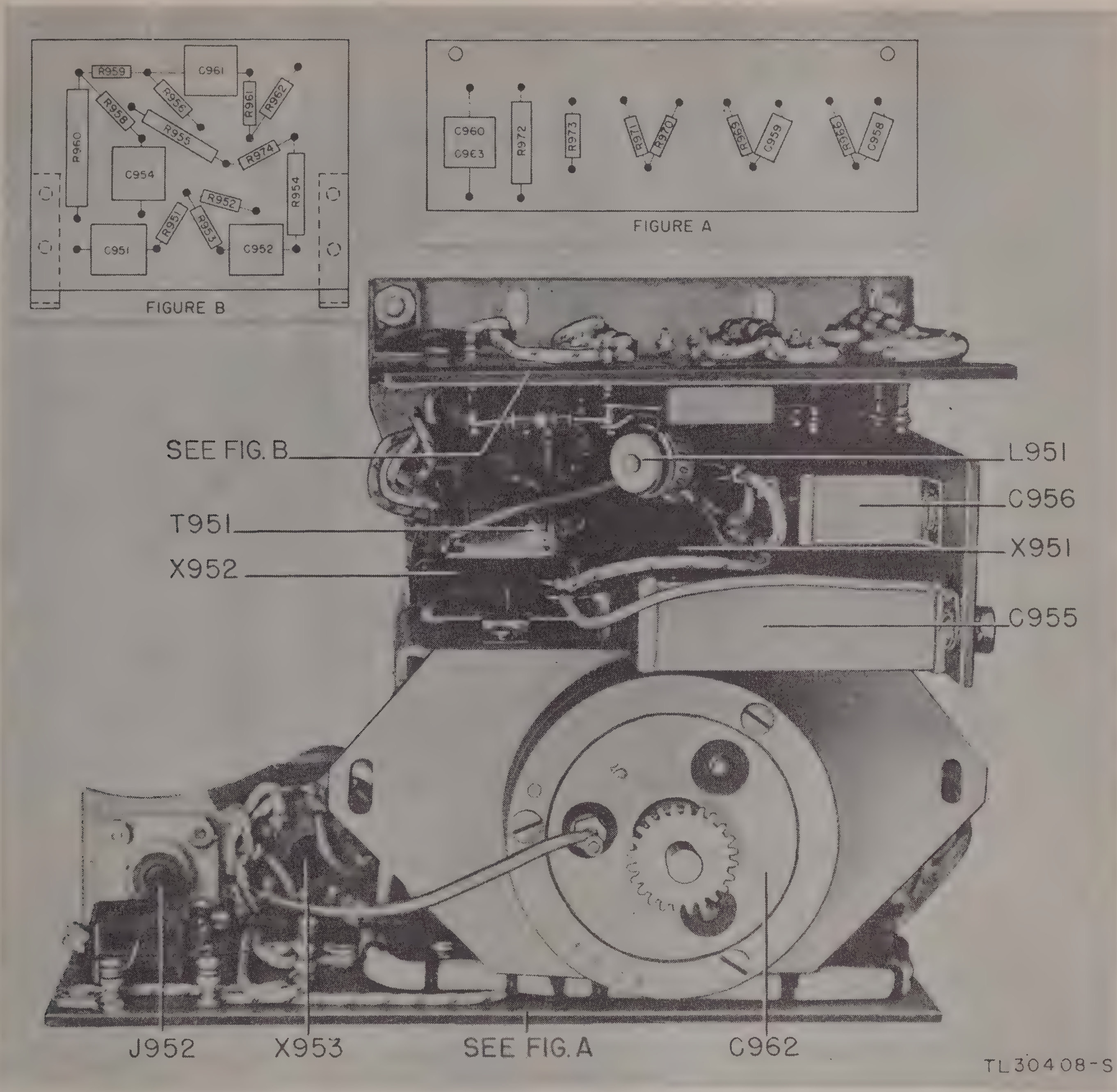

Figure 316. Automatic range tracking phase shifter, parts identified.

and test jacks J2113 or J2114. With this connection, five cycles of the 410-kc sine wave should be visible on the 2,000-yard range scope. The final check on the frequency however should be the ability of the gate and hairline to stay locked together.

(*3*) With the test oscilloscope connected to test jacks J2113 or J2114, set the ENVELOPE control so that the amplitude of the sine waves observed on the test scope remains constant throughout the range. Whenever the setting of this control is changed, the frequency of the oscillator should be checked, for the ENVELOPE control has a slight effect on the frequency.

280. BALANCE AND PHASE CONTROLS.

There are two balance controls and two phase controls on the oscillator phase shifter chassis of the range indicator and two balance controls on the automatic range tracking unit chassis. None of these controls should require adjustment unless circuit components affecting their settings are changed.

a. Balance Controls. To set the balance controls, two resistors between 50,000 and 250,000 ohms, equal to each other to within 1 percent, should be connected in series across the output terminals of the transformer associated with the controls to be set (T951 on the range indicator,

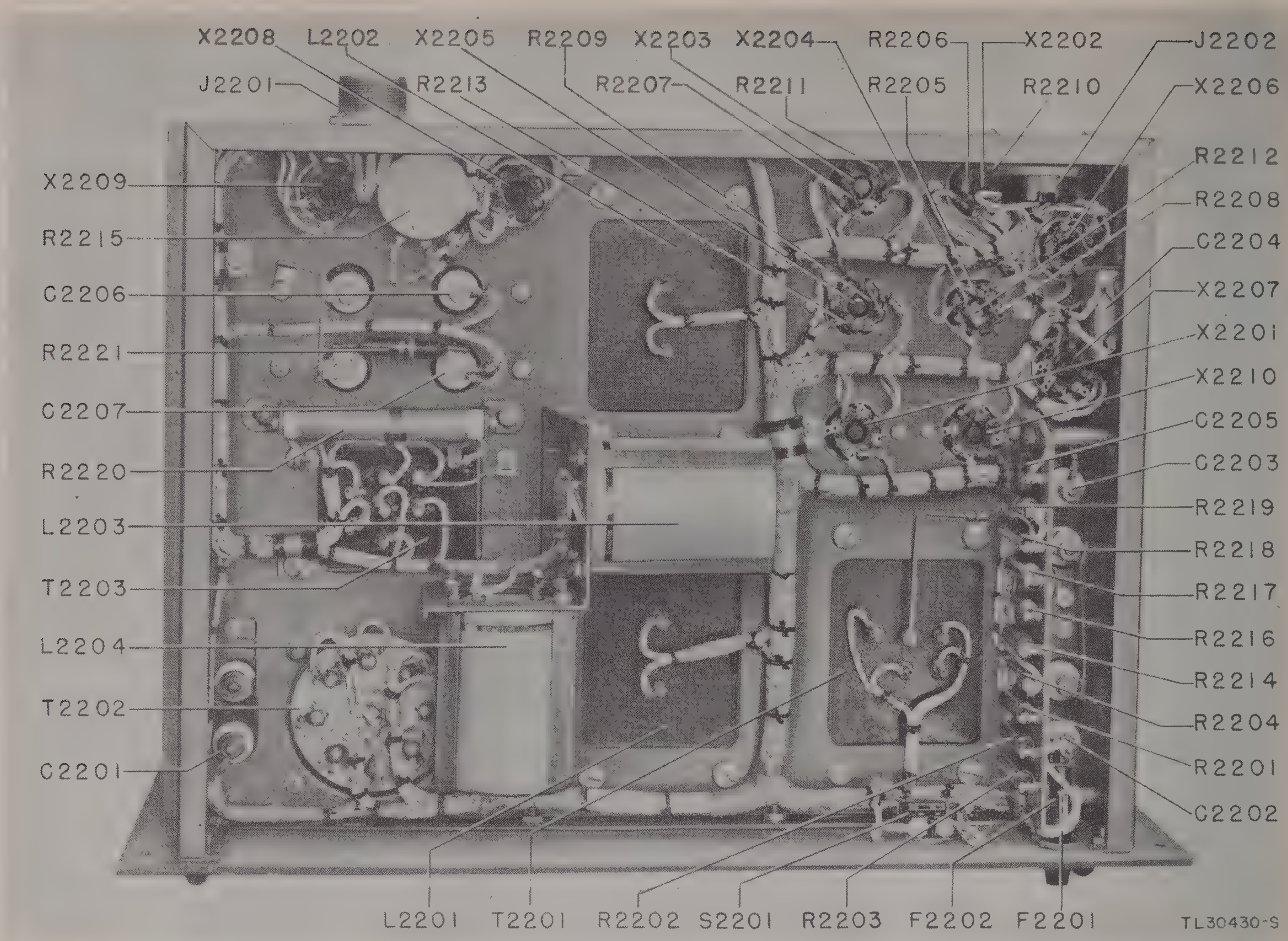

Figure 317. ART power supply, bottom view, parts identified.

or T2103 on the automatic range tracking unit). Connect the test oscilloscope between the chassis ground and the junction of the two resistors placed across the transformer windings. With the scope amplifier advanced, the signal should be reduced by balancing the 410-KC BALANCE controls until a null is reached. It should be possible to reduce the signal to a very low value. Tighten the lock on the adjustments, and remove the test resistors from the circuit.

b. Phase Controls. The two phasing controls on the oscillator phase shifter chassis of the range indicator adjust the sine waves on the plates of the phase shifting capacitor so that the sine waves on any plate are 90 degrees out-of-phase with the sine waves on the adjacent plate.

(*1*) Disconnect the cable from J913 on the range indicator and connect it to the MONITORING jack on the range indicator. Use an extenstion cable if necessary. Turn the MARKER INTENSITY control on the ART unit to get a ¼-inch deflection on the 2,000-yard scope. Look through the hole stenciled ZERO ADJUST in the chassis of the oscillator phase shifter unit and position the shaft of the phase shifting capacitor by turning the SLEWING handwheel so that the slot in the shaft of the capacitor is perfectly in line with the slot through the shoulder of the capacitor (fig. 133), with the "flat" on the capacitor shaft adjacent to terminal 1 of this capacitor. Record the position of the fine range hairline for this position of the capacitor shaft and mark the position of the leading edge of the deflection signal on the 2,000-yard scope. Rotate the capacitor counterclockwise 360° by rotating the range hairlines 400 yards with the SLEWING handwheel in equal steps of 100 yards. This will rotate the capacitor in four equal steps of 90 degrees. Record the position of the leading edge of the deflection signal for each of these 100-yard steps. Subtract the successive readings of the leading edge of the

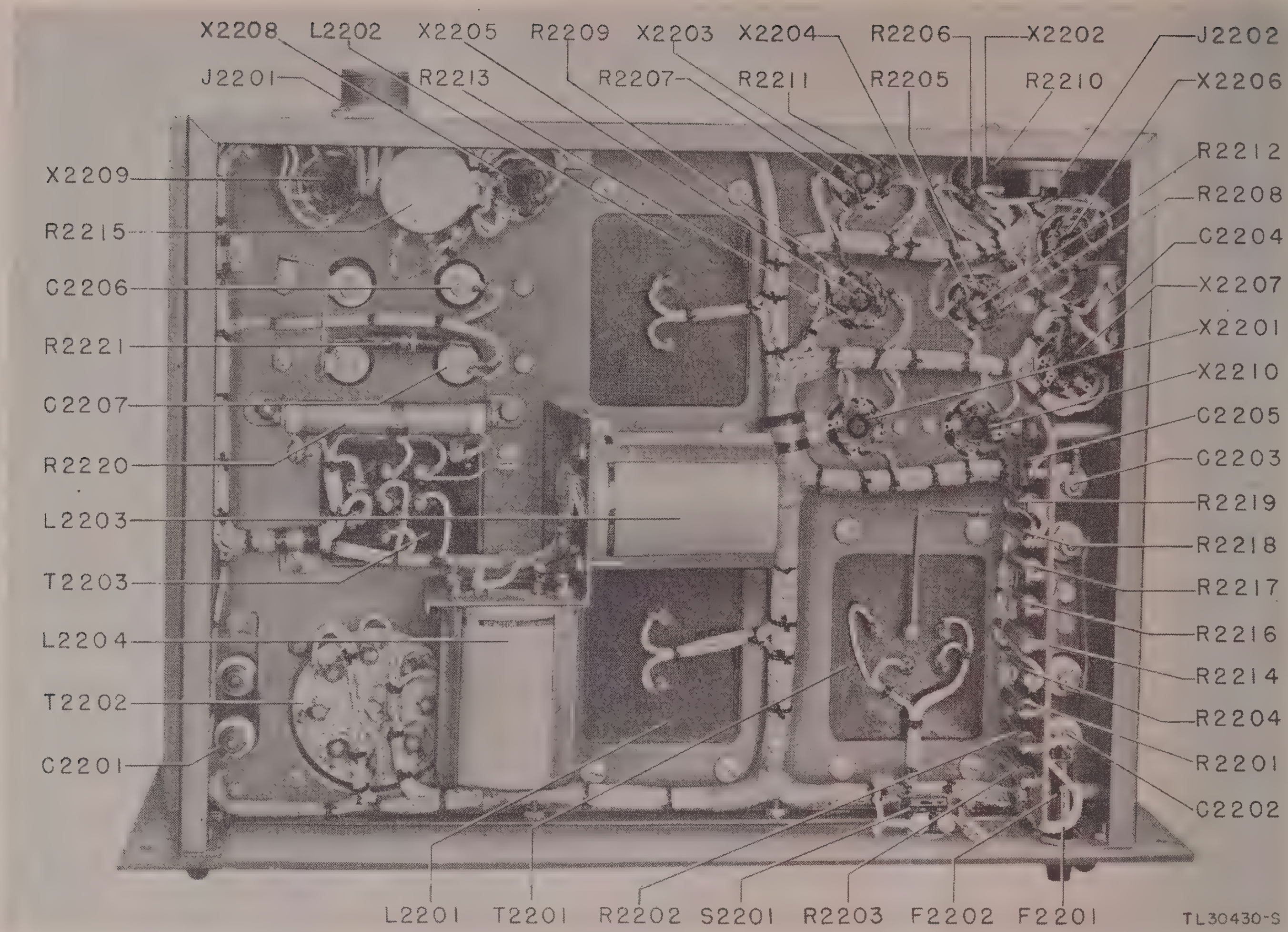

Figure 317. ART power supply, bottom view, parts identified.

or T2103 on the automatic range tracking unit). Connect the test oscilloscope between the chassis ground and the junction of the two resistors placed across the transformer windings. With the scope amplifier advanced, the signal should be reduced by balancing the 410-KC BALANCE controls until a null is reached. It should be possible to reduce the signal to a very low value. Tighten the lock on the adjustments, and remove the test resistors from the circuit.

b. Phase Controls. The two phasing controls on the oscillator phase shifter chassis of the range indicator adjust the sine waves on the plates of the phase shifting capacitor so that the sine waves on any plate are 90 degrees out-of-phase with the sine waves on the adjacent plate.

(*1*) Disconnect the cable from J913 on the range indicator and connect it to the MONITORING jack on the range indicator. Use an extenstion cable if necessary. Turn the MARKER INTENSITY control on the ART unit to get a ¼-inch deflection on the 2,000-yard scope. Look through the hole stenciled ZERO ADJUST in the chassis of the oscillator phase shifter unit and position the shaft of the phase shifting capacitor by turning the SLEWING handwheel so that the slot in the shaft of the capacitor is perfectly in line with the slot through the shoulder of the capacitor (fig. 133), with the "flat" on the capacitor shaft adjacent to terminal 1 of this capacitor. Record the position of the fine range hairline for this position of the capacitor shaft and mark the position of the leading edge of the deflection signal on the 2,000-yard scope. Rotate the capacitor counterclockwise 360° by rotating the range hairlines 400 yards with the SLEWING handwheel in equal steps of 100 yards. This will rotate the capacitor in four equal steps of 90 degrees. Record the position of the leading edge of the deflection signal for each of these 100-yard steps. Subtract the successive readings of the leading edge of the

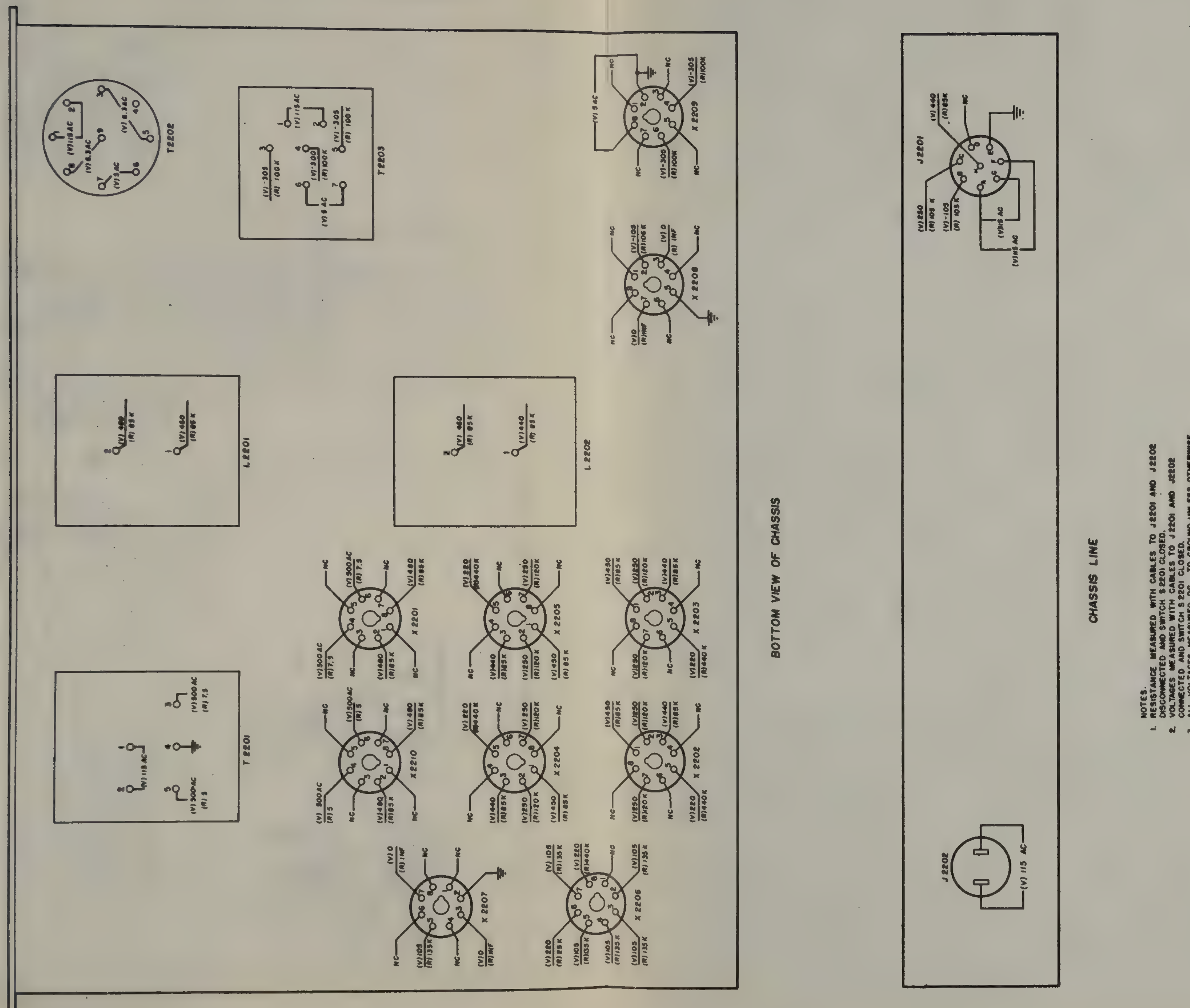

Figure 318. ART power supply, voltage and resistance chart.

Figure 318. ART power supply, voltage and resistance chart.

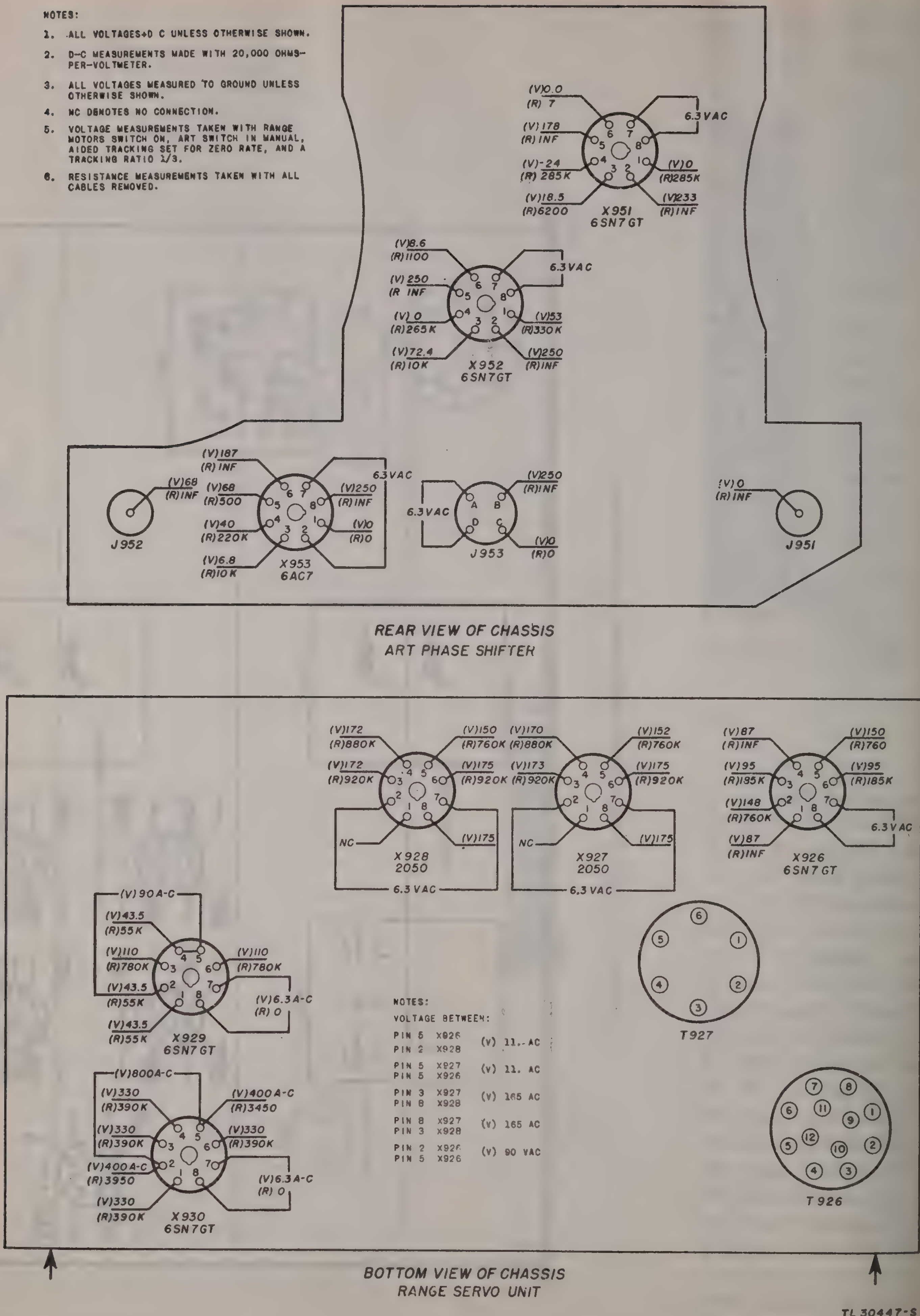

Figure 319. Automatic range tracking phase shifter and servo control, voltage and resistance chart.

deflection signal. The values for the angular rotation of the signal for each 90-degree rotation (100 yards) should agree within 5 yards.

(*2*) Readjust the PHASE BALANCING potentiometer R967 and R968 and retake the data as above. Turn R967 clockwise to increase the angular rotation of the signal for the first 90 degrees (100 yards) of rotation and R968 for the third 90 degrees (200 to 300 yards) of rotation. If it is impossible to obtain the proper balance, repeat the balance control adjustments as in subparagraph **a.**

281. MARKER INTENSITY.

The MARKER INTENSITY control should be set to suit the operator. The setting that makes the N^2 gate spot on the range scopes brightest is the proper setting.

282. BIAS GATE.

The bias gate control adjusts the amount of signal required to operate the gate tracker. If too low a setting is used, video noise will cause the tracker to drift. If too high a setting is used, the tracker will not lock on a weak target signal. The adjustment of this control is made with the RANGE TRACKING switch on the control panel in the AUTOMATIC position and the receiver VOLUME control turned up to a normal amount of grass on the range scopes. The bias control is then turned until the gate drift is minimized.

283. COAST RATE.

The COAST RATE control varies the gain of the second d-c amplifier in the automatic range tracking unit. This control is set properly when the tracking rate is the same in COAST as it is in AUTOMATIC when a target is being tracked in range. Select a target traveling about 250 miles per hour and track the target automatically. Allow at least 10 seconds to elapse, and then press the COAST button for 4 seconds. The N^2 gate and hairline should retain their position with respect to the video signal and when the COAST button is released the N^2 gate should remain locked on the video signal. If not, adjust R2182 (COAST RATE) and repeat the above procedure until it remains locked.

Oscillator Output
Test point, J611
Indication on 32,000-yd scope
Normal setting of controls

Trigger Generator Output
Test point, J622
Indication on 32,000-yd scope
Normal setting of controls

20-kc Multivibrator
Test point, J612
Indication on 2,000-yd scope
Normal setting of controls

20-kc Multivibrator
Test point, J612
Indication on 32,000-yd scope
Normal setting of controls

5-kc Multivibrator
Test point, J613
Indication on 32,000-yd scope
Normal setting of controls

1.7-kc Multivibrator
Test point, J614
Indication on 32,000-yd scope
Normal setting of controls

Clipper Output
Test point, J615
Indication on 32,000-yd scope
Normal setting of controls

Narrow Gate Delay Multivibrator
Test point, J616
Indication on 32,000-yd scope
Range potentiometer at maximum,
Other controls normal

Figure 320a. Range unit, test waveforms.

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Narrow Gate Delay Multivibrator
Test range, J616
Indication on 32,000-yd scope
Range potentiometer at minimum,
Other controls normal

Narrow Gate Width Multivibrator
Test point, J625
Indication on 32,000-yd scope
Range potentiometer at minimum,
Width control at maximum

Wide Gate Delay Multivibrator
Test point, J617
Indication on 32,000-yd scope
Delay control at maximum

Wide Gate Delay Multivibrator
Test point, J617
Indication on 32,000-yd scope
Delay control at minimum

Wide Gate Width Multivibrator
Test point, J624
Indication on 32,000-yd scope
Delay control at minimum,
Width control at maximum

Trigger Gate Delay Multivibrator
Test point, J618
Indication on 32,000-yd scope
Trigger delay control set to show first trigger pip

Trigger Gate Width Multivibrator
Test point, J623
Indication on 32,000-yd scope
Trigger delay control adjusted so that second trigger pip is centered in gate

Trigger Output
Test point, J620
Indication on 32,000-yd scope
Normal setting of controls

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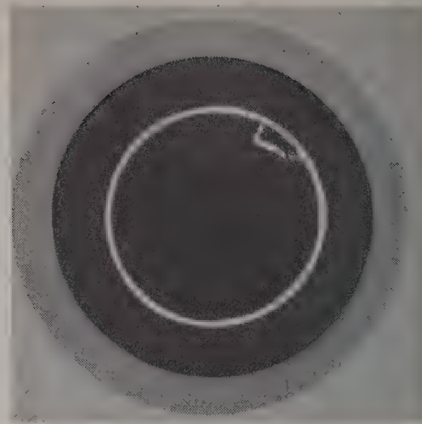
Figure 320b. Range unit, test waveforms.

Input Multivibrator Output

Test point, J2112
Use test scope

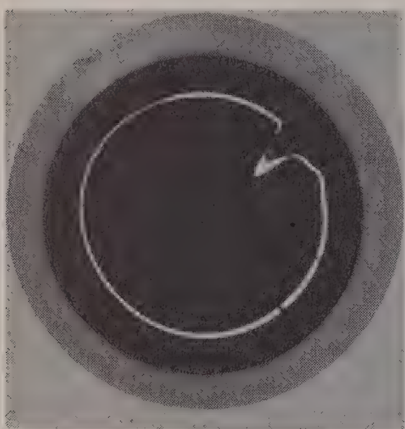
Saw-tooth Delay Output

Test point, V2106 pin 4
Use test scope
N^2 gate at 16,000 yds



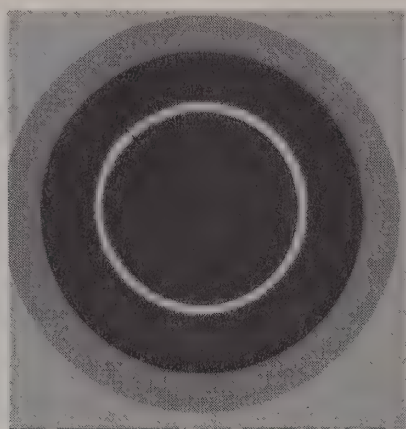
Illuminating Gate

Test point, J2115
32,000-yd scope



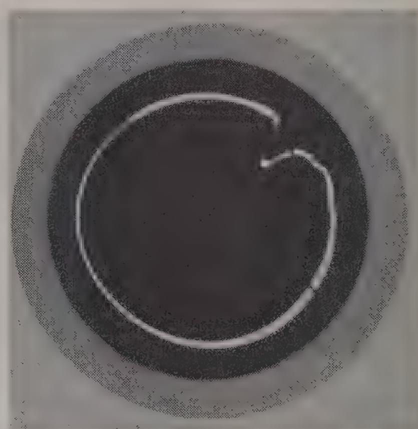
N^2 Gate to Receiver

Test point, J2116
2,000-yd scope



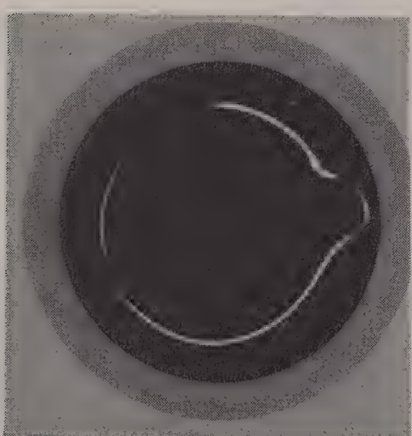
410-Kc Oscillator

Test point, J2113 or J2114
32,000-yd scope

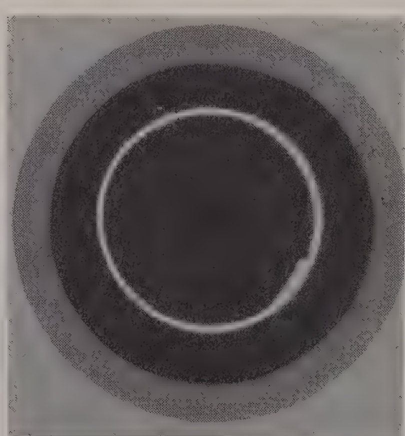


N^2 Gate to Servo and Gate Trackers

Test point, J2117
2,000-yd scope



Appearance of target on 2,000-yd range scope



Illuminating Gate to Range Indicator

Test point, J2104
32,000-yd scope

Illuminating Gate Generator Input

Test point, V2113 pin 1
32,000-yd scope

TL-30437-S

Figure 321. ART unit, test waveforms.

CHAPTER 17

TROUBLE SHOOTING IN THE PLAN POSITION (PPI) SYSTEM

WARNING: *Voltages sufficiently high to cause death on contact exist in the PPI system. Special care must be taken while working near the PPI tube and power supply. Do not make any connections which will bring high voltage out to an exposed point. When possible, make tests with the high voltage off.*

284. REFERENCE DATA.

The following reference data is included to assist maintenance personnel in trouble-shooting procedures on the PPI system.

a. Figure 148, PPI system, complete block diagram.

Figure 149, PPI system, cabling diagram.

Figure 171, PPI system, main power interlock unit.

b. Figure 173, PPI unit, complete schematic diagram.

Figures 327 and 328, PPI unit, test waveforms.

Figure 324, PPI unit, voltage and resistances.

Figure 325, PPI unit, bottom view, parts identified.

Figure 151, PPI unit, top view.

c. Figure 170, PPI power supply, top view.

Figure 323, PPI power supply, voltage and resistance diagram.

Figure 322, PPI power supply, bottom view, parts identified.

d. Figure 326, PPI, cutaway.

e. Figure 174, PPI indicator, complete schematic diagram.

285. GENERAL TROUBLE-SHOOTING PROCEDURE.

The information in this paragraph is used in conjunction with the trouble-shooting chart as an aid in interpreting and testing for troubles. The preparation necessary for making a test as well as the action of potentiometers within the circuit are given. Figures 325 and 322 locate all parts in order to speed the location of a trouble.

a. Multivibrator. Faulty operation of the multivibrator is caused by a fault in the multivibrator itself or by absence of a trigger pulse used to trip the multivibrator. Test jack J1610 is used to determine whether the multivibrator is functioning properly. Compare the waveforms obtained at the test jack to those in figures 327 and 328. If the waveform is abnormal, the fault can be localized either in the trigger circuit, or in the multivibrator itself. The amplitude should be between 70 and 95 volts. The scope should be synchronized with the 1.707-kc trigger output of the range unit which can be taken from jack J620. Adjust the sweep frequency so that two cycles of the square wave appear.

(*1*) On the 35,000-yard range, the width of the negative wave should be between 210 microseconds (35,000 yds) and 250 microseconds (42,000 yds).

(*2*) On the 70,000-yard range, the width of the negative wave should be between 420 microseconds (70,000 yds) and 520 microseconds (85,000 yds).

(*3*) In the 70,000-yard position, the multivibrator triggers only every other cycle because of the long time constant. This has the effect of making the intensity approximately the same on the two ranges.

b. Sweep Intensifier. When no trace is obtained on the scope, the fault may be because of

a defect in Indicator BC-1092-C, Rectifier RA-69-A, or Plan-Position Unit BC-1058-C. The INTENSITY control should be advanced to determine whether or not this adjustment produces a visible trace. Faulty operation of the sweep intensifier circuit shows up as improper intensity of the sweep. Test jack J1612 is provided so that the voltage at the cathode of the sweep intensifier tube (also the cathode of the PPI tube) can be checked. The waveforms which appear at this jack are shown in figures 327 and 328. If the multivibrator or sweep intensifier stage is not functioning, the INTENSITY control can be advanced temporarily so as to provide an indication on the scope to assist in trouble shooting. When a sweep but no video signals appear on the PPI scope, the fault is probably in the cable and connectors which carry the video signal from the remote video unit to the PPI unit or in the signal inverter, the d-c restorer, or the signal mixer. The fault may be localized by replacement of tubes or signal tracing.

(*1*) The amplitude of the negative square wave should vary from 17 to 30 volts ± 20 percent as the INTENSITY control is turned from full clockwise to full counterclockwise.

(*2*) The d-c voltage at jack J1612 should vary from 90 volts ± 10 percent to 35 volts ± 10 percent when the INTENSITY control R1614 is turned from full clockwise to full counterclockwise.

c. Selsyn Driver. When a spot, but no sweep, is obtained on the PPI scope, although the spot can be positioned by rotation of the horizontal and vertical CENTER ADJUST controls, the trouble is probably in stages preceding the output tubes. Test jack J1611 across the cathode resistor of the selsyn driver tube V1601 is a convenient test for a measurement at this point to determine if the saw-tooth generator is operating. The waveform of the current through the rotor of the selsyn is also obtainable at this jack. The waveform should appear as in figures 327 and 328. The rising edge of the sweep should be practically a straight line. The voltages at the output of the selsyn cannot be checked conveniently from the top of the chassis. However the horizontal and vertical amplifier-inverter tubes V1606 and V1607 can be removed from their sockets and the waveforms at grid (4) of tube V1606 and grid (1) of tube V1607 checked. The waveform at these points should vary in polarity and amplitude with the rotation of the PPI selsyn.

(*1*) The amplitude of the sweep waveform should vary from about 30 to 70 volts ± 20 percent when potentiometer R1605 (35,000-yd SWEEP) is turned from full counterclockwise to full clockwise rotation (fig. 328).

(*2*) The amplitude of the sweep waveform should vary from about 30 to 70 volts ± 20 percent when potentiometer R1604 (70,000-yd SWEEP) is turned from full counterclockwise to full clockwise rotation. Check to see that the rising edge of the sweep is a straight line.

d. Amplifier-inverter Stages. When checking the sweep waveform at jack J1613 with the test scope, turn the PPI selsyn slowly through one revolution. The amplitude of the sweep waveform should change from positive to negative. The rising edge should remain very nearly a straight line during the entire revolution.

(*1*) Check the positive and negative sweep waveforms against figures 327 and 328. The maximum amplitude of sweep voltage (either positive or negative) should be 16 volts ± 30 percent. The sweep waveform should be clean, and free from 60-cycle modulation.

(*2*) Check the sweep waveform at jack J1614 and repeat the procedure above. The waveforms at jack J1614 should be as shown in figures 327 and 328. The sweep waveform amplitude should not be greater than 5 percent of the maximum observed in (*1*) above.

e. Sweep Output Amplifiers. When a spot, but no sweep, is obtained on the PPI scope the output amplifier may be at fault. A simple check for this is to note the effect of the centering adjustments on the position of the spot. When either the horizontal or vertical CENTER ADJUST controls is moved through its extreme rotation, the movement of the spot should be in the appropriate direction. If this movement does not take place, a fault is indicated in the output tubes, clamping tubes, or the deflection coils. When making this test, mark the original position of the screw setting before attempting to turn it. After the test, return the settings to their original positions.

(*1*) The trigger amplifier, the clipper tubes in the range marker circuit, and the horizontal and vertical clamping tubes receive their bias from the voltage drop produced by the plate

current of the horizontal and vertical output amplifiers flowing through the common resistors in their cathode circuits. For this reason, improper operation of the output amplifier tubes affect the operation of the stages mentioned because of the effect on the plate current of these stages. The output tubes should not be removed to make waveform measurements at the tube socket because removal of the tubes affects the bias voltages produced and hence the waveforms.

(*2*) To check the output amplifiers remove multivibrator tube V1603. Measure the d-c voltage between pins C and K on jack J1603. Turn the CENTER ADJUST potentiometer R1679 from full counterclockwise to full clockwise position; the voltage between pins C and K should vary from about minus 25 to plus 25 volts ± 30 percent, pin C being the reference point.

(*a*) Set the CENTER ADJUST potentiometer R1679 so that the voltage between pins C and K is zero. Measure the d-c voltage between pins J and A on jack J1603. Turn the CENTER ADJUST R1682 potentiometer from full counterclockwise to full clockwise position; the voltage between pins J and A should vary from about minus 32 to plus 20 volts, pin J being the reference point.

(*b*) Set CENTER ADJUST potentiometer R1682 so that the voltage between pins J and A is zero. Insert the multivibrator tube V1603. Check the waveform at plate 3 of tube V1617. Turn the PPI selsyn to obtain maximum positive sweep amplitude. The amplitude of the sweep wave form should be 50 volts ± 25 percent. See figures 327 and 328. Check to see that the sweep waveform is clean.

(*c*) Check the waveform at tube V1616, plate 3. Observe the negative sweep waveform. This should be as shown in figures 327 and 328. Turn the CIRCLE ADJUST potentiometer R1638 from full counterclockwise to full clockwise position; the amplitude of the sweep waveform should vary 15 volts ± 30 percent. The maximum amplitude should be 60 volts ± 25 percent.

(*d*) Check tubes V1618 and V1615 in the same manner as tubes V1617 and V1616.

f. Focus Coil. When measuring the d-c voltage across the pins of terminal board TB 2 in the PPI indicator, remove the high-voltage rectifier tube V1503 from its socket as a safety precaution. Turn the FOCUS control R1674 from the full counterclockwise to the full clockwise position to check the coil. The voltage on pin F of jack J1702 to ground should vary from 0 to 50 volts ± 20 percent.

g. Range Marker Circuit. The range marker circuit consists of the range marker oscillator, the two clipper stages, and the range marker generator. No test jacks are included in this circuit, although the test jack J1616 in the cathode circuit of the signal mixer stage shows the range marker pips. The performance of the range marker channel can be checked by comparing the observed waveforms taken with the test scope with the standard waveforms shown in figures 327**a** and 328**a**. These waveforms are taken with the video and the narrow gate signal inputs removed from the PPI unit. The RANGE MARKER and the NARROW GATE controls are set at maximum. Replacement of tubes and the measurement of resistance and voltage at the tube sockets may be tried before using the extension cables to make waveform measurements at the underside of the chassis.

h. Video Signal Channel. The maximum amplitude of the video signals at the output of the signal mixer jack J1616 should be about 70 volts as measured on the test oscilloscope; the video signals are limited to this value by the clipping action of the signal inverter stage.

286. PLAN POSITION POWER SUPPLY.

This paragraph lists the method of testing various parts in the plan position power supply as well as in the proper test points. The functions of each power supply section is given in order to help locate a trouble in the power supply more easily.

a. High-voltage Half-wave Rectifier.

(*1*) The high-voltage half-wave rectifier feeds a two section R-C filter and provides an output of 4,500 volts across the 5-megohm bleeder formed by the eleven 470,000-ohm resistors. Trouble in the power supply results in loss of intensity on the PPI scope and complete failure of the trace if the power supply drops to a low value. The best way of checking this power supply is by means of resistance measurements with the power off. Normal resistance values are given in figure 323. It is not recommended that the high-voltage output of the rectifier be measured directly.

(2) The output of the high-voltage power supply can be measured indirectly by measuring the voltage drop across the first resistor of the 11 resistors which make up the bleeder. The voltage across resistor R1528 (make certain that one side of the resistor across which the voltmeter is connected is grounded before connecting the voltmeter) should have the following values if the output voltage across the bleeder is 4,500 volts:

(a) For a 20,000-ohm-per-volt meter approximately 380 volts.

(b) For a 1,000-ohm-per-volt meter approximately 270 volts. Both of the above measurements are with the voltmeter set on the 1,000-volt range.

(3) *Heater Voltage Measurement.* Great care should be taken in measuring the heater voltage of tube V1503. If it is necessary to measure this voltage, turn the power off, connect the voltmeter, and turn the power on. *Do not handle the voltmeter or leads when the power is applied because the entire voltmeter is 5,000 volts above ground potential.*

(4) *Damaged Filter Capacitor.* If a filter capacitor breaks down, it is likely that the rectifier tube is damaged. Before replacing the tubes, a resistance check should be made to prevent damage to a new tube by the same fault responsible for the failure of the original tube.

b. 300-volt Unregulated Supply. This full-wave rectifier feeds the clamping tubes, range marker tubes, focus coil of PPI scope, and the first anode of the PPI scope in the PPI unit. Test jack J1609 on the PPI unit is provided for measuring the output voltage. The voltage changes with the setting of the FOCUS control R1674 because the center tap on the high-voltage secondary winding is returned to ground through the focus coil which is in parallel with this control. Trouble shooting on this supply should be carried out with the FOCUS control set so that the negative end of the filter is grounded.

c. 270-volt Regulated Supply.

(1) The 270-volt regulated supply furnishes plate voltage for the trigger amplifier, multivibrator, saw-tooth generator, sweep intensifier, selsyn driver, signal inverter, and signal mixer, output amplifiers, and amplifier-inverter stages. The output voltage can be measured by connecting a voltmeter to test jack J1608 in the PPI unit. Refer to the complete schematic in the theory section for the interconnections between the power supply and the other components.

(2) The operation of this supply is described in section IV of chapter 6. Like the 300-volt unregulated supply, the negative end of the supply is returned to ground through the focus coil in parallel with the FOCUS control. However, the output voltage is maintained constant at 270 volts regardless of the setting of the FOCUS control.

(3) The simplified diagram of the regulated power supply is shown in figure 172. It is useful as a reference when trouble shooting. If a fault develops in the voltage-regulating circuit, it can be located most easily by measuring the voltage at the control grid plate and cathode of tube V1506, and the input of the regulator tubes (plate of tube V1504).

(4) The voltage at the control grid is set by means of the VOLTAGE ADJUST control R1506 and it should be adjusted so that the output measured at jack J1608 on the PPI unit is 270 volts. For this condition the voltage at the control grid must be a few volts negative with respect to the constant voltage (approximately 105 volts) maintained at the cathode by means of the VR-105-30 voltage regulator tube V1507 Abnormally high voltage output from this supply indicates a fault in the regulator circuit, which is preventing the control tube V1506 from drawing its normal current. Normally the control grids of the two regulator tubes are maintained at an operating potential of about + 240v, which provides a bias of about 30 volts on the two regulator tubes. The fault may be due to a defective control tube or improper voltages on the control tube. In particular, make certain that the voltage difference, as measured with the positive end of the voltmeter connected to the cathode of the control tube, shows the grid of the control tube to be a few volts negative with respect to the cathode. If the range of the VOLTAGE ADJUST control is insufficient to make the control grid negative with respect to the cathode, there is probably a fault in the voltage divider across the output of the supply. Make a resistance check.

287. TRANSFORMER WIRING AND INTERLOCKS. A simplified diagram showing the transformer wiring and the various cables and interlocks in the PPI system is shown in figure 171. This diagram is helpful in localizing faults in the PPI power distribution system. Note that any of the following removes power from the three plate transformers feeding the three rectifiers:

a. Removal of tube V1507 from its socket.

b. Removal of the rear cover from the PPI shield.

c. Disconnecting the cable to the PPI selsyn.

d. Disconnecting the low-voltage power cable to the PPI unit.

e. Disconnecting the low-voltage power cable to the PPI indicator.

288. PLAN POSITION SYSTEM, TROUBLE-SHOOTING CHART.

A. SYMPTOMS: 1. No spot on the PPI scope.
2. Range scope normal.
3. Pilot lights illuminating PPI scale are lighted.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Sweep intensifier circuit.	1*a*. Turn up the INTENSITY control. If no spot or trace appears, leave the INTENSITY control turned up and proceed to step 2 below. *b*. Measure the voltage at jack J1612 and compare waveforms to those of figure 327**b**. *c*. Check the voltage divider feeding the cathode of the sweep intensifier, using the voltage-resistance chart (fig. 324).
2. PPI filament voltage supply.	2. Check the filament voltage of the PPI tube. The filaments are supplied from the same filament winding of transformer T1601 which supplies the pilot lights illuminating the PPI scale. Check voltage and compare with voltage-resistance chart (fig. 323). If the voltage is abnormal, the fault is in the transformer or in the connections to the transformer winding.
3. Deflection circuit.	3*a*. Excessive current through the deflecting coils keeps the spot deflected off the screen. Check by either short-circuiting the two deflecting coils, or removing the four output tubes V1615 to V1618 from their sockets. This makes the current through the deflecting coils drop to zero so that the spot should be approximately in the center of the screen. *b*. If there is still no spot, the PPI tube is defective. Take voltage and resistance readings according to chart in figure 323. *c*. If step 3*a* is performed and a spot or trace appears, then the fault is probably because of an unbalance in the sweep amplifier output tubes. Check between pins C and K and A

and J of receptacle J1603, and compare the voltages to the chart in figure 324. If one of these voltages is zero, there is an open in the deflection coil. Shut off the power and make a continuity check. See figure 324.

d. If the voltages are unbalanced, it indicates either a defective output tube or a fault in the clamping circuit. While making measurements in the clamping circuit remove the saw-tooth generator tube V1602 so that there is no unclamping voltage fed to the clamping tube. Measure the voltages at each of the control grids of the four output tubes. When the circuit is restored to the condition where the voltage across each pair of deflection coils (between pins C and K of receptacle J1603 and A and J of J1603) is zero, the spot should appear in the approximate center of the PPI screen.

B. SYMPTOMS: 1. Spot on the PPI scope.
2. No sweep on the PPI scope.
3. Range markers are present.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Sweep generator circuit.	1*a*. Measure voltage and waveforms at jack J1611. If the waveforms appear as in figure 327**b** for both range positions, perform step below.
	b. If the voltage at jack J1611 is abnormal, take voltage and resistance measurements (fig. 324).
2. Amplifier-inverter circuit.	2*a*. Check voltages and waveforms at jack J1613. Compare waveforms to those in figure 327**a**. If they are abnormal check tubes and take voltage and resistance readings (fig. 324).
	b. Check the voltage and resistance of the resistance network.
3. Output amplifiers.	3. Check the output tubes. If they are normal, take voltage and resistance readings (fig. 324).

C. SYMPTOMS: 1. Either 70,000-yd sweep or 35,000-yd sweep not visible.
2. Other sweep normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. RANGE SELECTOR switch.	1*a*. Check waveform at jack J1610. It should appear as figure 327**a**.

b. Check the contacts and action of RANGE SELECTOR switch.

c. Check resistors R1603 and R1604 and capacitors C1605 and C1606 if 70,000-yd sweep is bad.

d. Check resistors R1608 and R1605 if 35,000-yd sweep is bad.

D. SYMPTOMS:
1. PPI sweep is dim, distorted, and blurred on both the 35,000-yd and 70,000-yd ranges.
2. Echoes, narrow gate, and range markers not visible.
3. Range scopes normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. PPI unit or PPI power supply.	1*a*. Check the voltages at jacks J1608 and J1609 to be 270 volts and 300 volts, respectively. *b*. If the voltages are abnormal, the fault is either in the PPI power supply or the PPI unit. Remove the cable from jack J1602 and check the voltages at J and K on plug P1602 to determine whether the power supply is supplying the proper voltage. If abnormal, proceed to step 3.
2. Multivibrator of trigger circuit.	2*a*. Replace the trigger amplifier tube V1614 and the multivibrator tube V1603. If the fault continues, proceed with next step. *b*. Check the waveform at jack J1610 using the test scope synchronized with trigger pips from the range unit. See figure 327**a**. If normal, check the waveforms at jack J1611 and make a stage by stage resistance and voltage analysis. *c*. If the waveforms at jack J1610 are abnormal, the fault may be in either the trigger input, the trigger amplifier, or the multivibrator. If the multivibrator is operating and not receiving a trigger voltage the recurrence frequency is very low, approximately 100 cycles. *d*. Remove the trigger amplifier tube V1614 and check the waveform at the grid (fig. 327**b**). If abnormal, the fault is in the circuit between jack J606 in the range unit and the socket of tube V1614. If normal, the fault is in amplifier stages or in the multivibrator. Make a voltage analysis to locate the fault.
3. High-voltage power supply.	3. Make a voltage and resistance check of the high-voltage power supply feeding the second anode of the PPI tube.

4. 300-volt PPI power supply.	4. Check the unregulated power supply voltage at jack J1603-B for approximately 300 volts. If the voltage is abnormal, make a voltage and resistance check of the 300-volt unregulated supply.
5. Focus voltage supply.	5. Check the focus voltage. If the voltage is abnormal, check the connections to the focus coil. Note that the focus coil and its shunt resistor carry the total current of the two low-voltage PPI power supplies. If the voltage is normal, continue with next step.
6. Deflection circuit.	6. This step is the same as step 3 of symptom A.

E. SYMPTOMS: 1. Sweep off-center.
2. All other indications are normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Clamping or output tubes.	1*a*. Remove the multivibrator tube V1603. The trace narrows down to a spot. *b*. Check the voltage difference between the plates of sweep output tubes by measuring between pins C and K of jack J1603 and A and J of jack J1603. The voltage difference should be approximately zero. If the voltage difference between the plates of either pair is abnormal, the fault is either in the circuit of the output tubes or the clamping tubes. *c*. If the voltage difference is normal the fault is due to improper adjustment of the focus coil (par. 291). *d*. To enable the measurement of the d-c clamping voltage without interference from the multivibrator square wave, remove the multivibrator tube V1603. Check the clamping voltages at the grids of the output tubes. *e*. If the clamping voltage is abnormal, the clamping tube is probably defective. Try another tube and if that does not clear the fault, make a voltage and resistance check to locate the fault. *f*. If the clamping voltage is normal, one of the output tubes is probably defective. Replace the tube.

F. SYMPTOMS: 1. Intermittent PPI trace during PPI scan.
2. All other indications are normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Poor contact at the slip rings of the PPI selsyn B2005 located in the pedestal.	1*a*. Remove the end cap from the PPI selsyn B2005 and clean as described in TM 11-

1454 paragraph 20. If this does not clear the fault, move the contact brush arm very slightly so that the contact surface on the slip ring is changed. Replace the cap on the selsyn.

b. Check all connections to the selsyn.

c. If all the connections are secure, replace the selsyn B2005.

2. Sweep intensifier.	2*a.* Check the voltage and waveform at jack J1612, (fig. 327). *b.* Replace the tube. *c.* Take voltage and resistance readings according to chart in figure 324.

G. SYMPTOMS: 1. Intensity of the PPI sweep cuts out intermittantly or completely.
2. All other indications are normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Break-down in the high-voltage cable or connectors for the second anode of the PPI scope.	1*a.* Check for visible sign of break-down in the high-voltage cable or connectors. *b.* A break-down in the high-voltage circuit must be located by inspection and substitution of suspected parts where a voltmeter with a 5,000-volt scale is not available. A resistance measurement may be made using the method outlined in paragraph 212. *c.* If the proper voltmeter is available, turn off the PPI power supply; momentarily short the second anode connection on the PPI scope to ground so as to make certain the high-voltage filter capacitor is discharged, and connect the voltmeter to the second anode. **CAUTION:** Do not touch the meter and test lead after the power is turned on. A low fluctuating voltage reading indicates a probable break-down. Replace the cable and repeat the test to determine whether the fault is in the cable or the power supply.
2. H-v power supply.	2. Check the high-voltage tube V1503 for poor emission. If the tube is all right, check the capacitors and resistors in the circuit.

H. SYMPTOMS: 1. Sweep off-center so that outer extremity of the PPI sweep is not visible during a portion of the PPI scan.
2. All other indications are normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Deflection coil.	1. Adjust the position of the deflection coil by means of the three deflection coil mounting

PROBABLE LOCATION OF FAULT	PROCEDURE
	screws (fig. 326) according to the procedure given in paragraph 290.
2. Clamping or output amplifier tubes.	2. This step is the same as step 1 of symptom E.

I. SYMPTOMS: 1. Range marker circles missing.
2. All other indications are normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. RANGE MARKER control.	1*a*. Turn up the RANGE MARKER control R1632. If the range markers appear and are normal, the control can be left in its position. The changed position of the control may have been made necessary by a change in the bias voltage on the clipper tubes or by a change in the tube characteristics. *b*. If the range markers are still absent, and the narrow gate shows up normally, the fault is in either the range marker oscillator, clipper, or generator stages.
2. Range marker tubes or circuit.	2*a*. Replace the range marker tubes V1604 and V1605. *b*. Make a resistance and voltage check to determine the defective stage. See the chart in figure 324. *c*. Check the waveform at successive points until a point is found at which the waveform is abnormal. From this information locate the fault by a stage analysis. The proper waveforms are shown in figure 327**a** and 328**a**.

J. SYMPTOMS: 1. Egg-shaped or distorted range marker circles.
2. All other indications are normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Amplifier-inverter tubes.	1. Replace the amplifier-inverter tubes V1606 and V1607 one at a time.
2. Selsyn driver stage.	2*a*. Determine whether the fault is ahead of the output of the selsyn driver stage. Check the waveform at jack J1611. The waveforms should correspond to those in figure 327. *b*. If the waveform is abnormal, the fault is in the selsyn driver or in the stages preceding it. Make a stage-by-stage analysis to locate the fault. If the waveforms are normal, the fault is located in the circuits following the selsyn driver.
3. PPI selsyn and Y-resistor network.	3*a*. Determine whether the fault is in the PPI selsyn or in the Y-resistor network, by using the test scope to measure the waveforms applied to grid 4 of tube V1606 and grid 1 of tube V1607. First check the voltage at grid 4 of tube V1606 and then the voltage at grid 1 of tube V1607. Compare

the waveforms to those of figure 327. The two waveforms should vary in the same way as the PPI selsyn rotates with the pedestal except that one voltage reaches its maximum 90 degrees of selsyn rotation ahead of the other.

b. If the waveforms are abnormal, the fault is in the PPI selsyn or in the Y-resistor network following it. Make a continuity check of this circuit using the voltage-resistance chart in figure 324. If the performance of the selsyn is in doubt, a spare may be substituted for it. If the waveforms are normal, the fault is in the amplifier-inverter and the output amplifiers following the input to the amplifier-inverter stages. See next step.

4. Amplifier-inverter.

4. Faulty operation in the amplifier-inverter and output stages are disclosed by a check of the waveforms at the plates of these tubes and the output tubes and noting the point at which distortion is first introduced.

K. SYMPTOMS: 1. No video signal on the PPI scope, with video signals on range scopes.
2. All other indications are normal.

PROBABLE LOCATION OF FAULT

1. Signal circuit.

PROCEDURE

1*a*. Check waveform at jack J1616 and compare to figure 327.

b. Check the video signal at the input to the PPI unit by removing tube V1608 and inserting the scope lead at pin 1 of tube V1608 socket. If no signal is present, the fault is between the output of the remote video amplifier and tube V1608 pin 1. Locate the fault by signal tracing. If signal is present at pin 1, try replacing tubes V1608 and V1609. If fault is still present, check voltages and resistances according to chart in figure 324.

L. SYMPTOMS: 1. Disappearance of noise level (grass) on the PPI sweep when strong signals are being received.
2. Weak signals are not present on PPI scope.
3. Strong and weak signals appear on range scope.

PROBABLE LOCATION OF FAULT

1. D-c restorer tube V1608-B.

PROCEDURE

1*a*. Replace tube V1608.

b. Replace tube V1609.

c. Check the circuit of the d-c restorer using the voltage and resistance chart in figure 324.

289. ALIGNMENT OF PPI SYSTEM.

The alignment of the PPI system should be made with the various components of the set completely assembled and with Radio Set SCR-784 operating normally. The various controls necessary for the alignment are located in figure 151.

a. Preliminary Adjustments.

(*1*) Turn the INTENSITY control on the front panel of the PPI unit to full counterclockwise position.

(*2*) Turn the RANGE SWITCH on the front panel of the PPI unit to the 35,000-yard position.

(*3*) Turn on the PPI power supply. The red indicator light should light, and the azimuth scale of the PPI scope should become illuminated.

b. Intensity Control. Allow about 30 seconds warm-up time, and turn the INTENSITY control slowly clockwise. A line should become visible on the face of the PPI scope. The brilliance of the line should increase with clockwise rotation of the control. Set the INTENSITY control so that the brilliance is low.

c. Focus Control. Focus the line by means of the FOCUS control on the front panel of the PPI unit. Because of the long persistence of the PPI tube, focusing must be done slowly. Final focusing should not be attempted until the PPI system has had about ½ hour to warm up.

d. Centering Controls. The inside end of the sweep line on the face of the PPI scope should be centered on the PPI scope by means of the CENTER ADJ controls located on the chassis

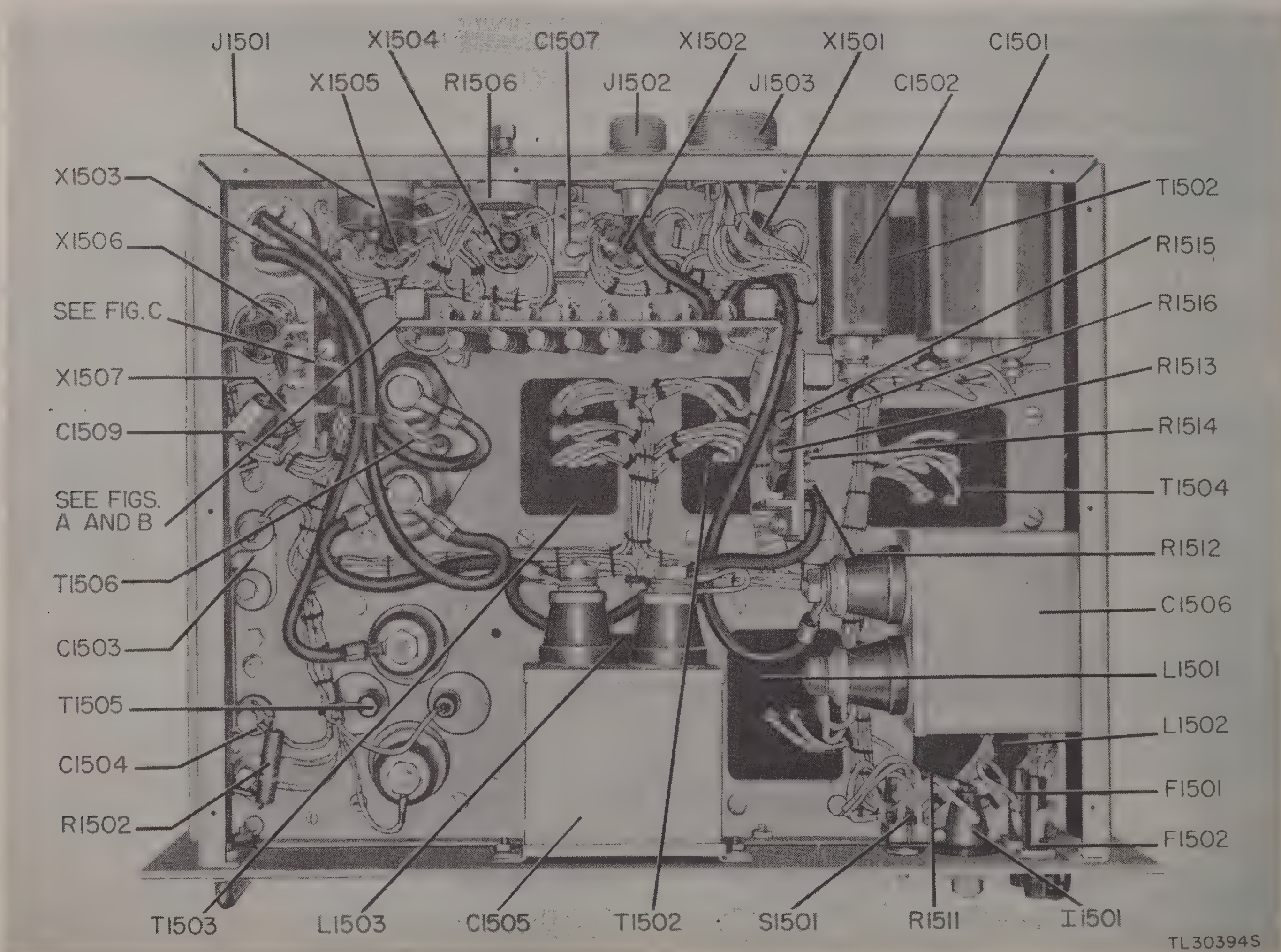


Figure 322. PPI power supply, bottom view, parts identified.

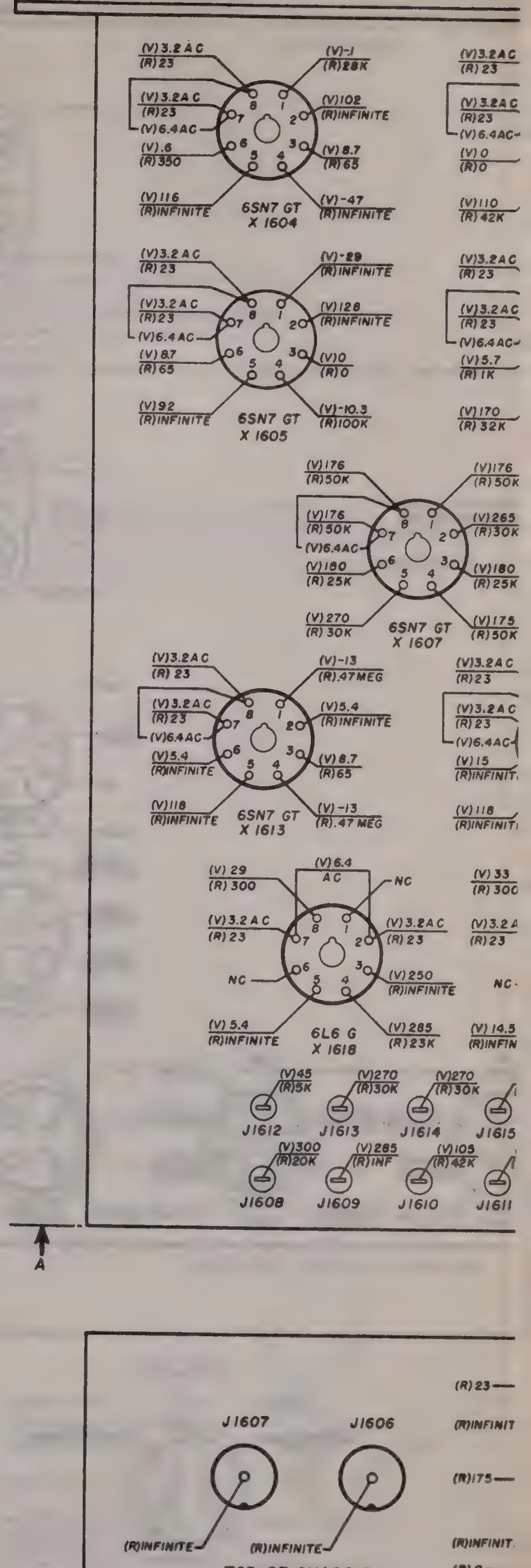


Figure 324. PPI unit, voltage and resistance chart.

289. ALIGNMENT OF PPI SYSTEM.

The alignment of the PPI system should be made with the various components of the set completely assembled and with Radio Set SCR-784 operating normally. The various controls necessary for the alignment are located in figure 151.

a. Preliminary Adjustments.

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c. Focus Control. Focus the line by means of the FOCUS control on the front panel of the PPI unit. Because of the long persistence of the PPI tube, focusing must be done slowly. Final focusing should not be attempted until the PPI system has had about ½ hour to warm up.

d. Centering Controls. The inside end of the sweep line on the face of the PPI scope should be centered on the PPI scope by means of the CENTER ADJ controls located on the chassis

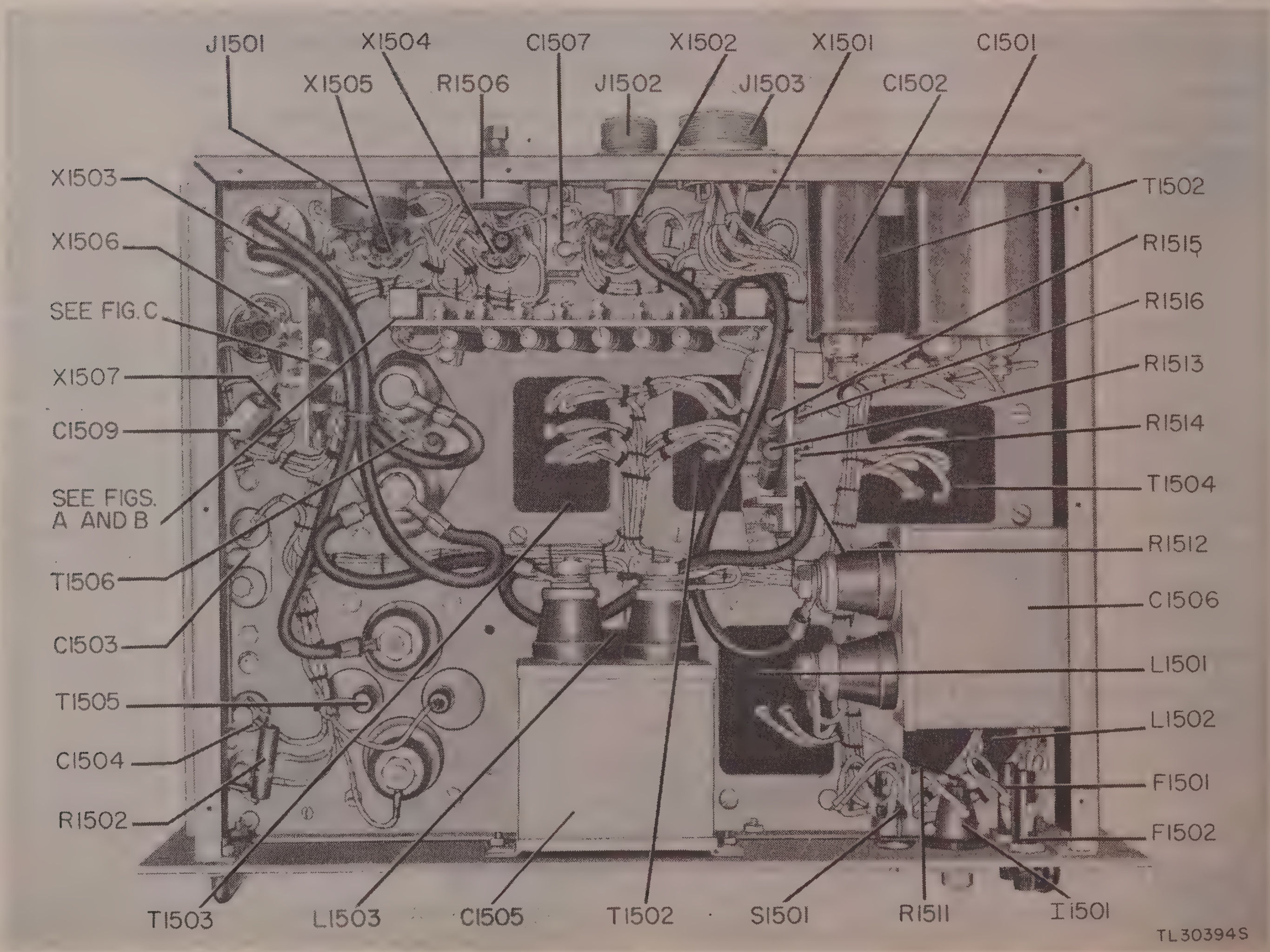


Figure 322. PPI power supply, bottom view, parts identified.

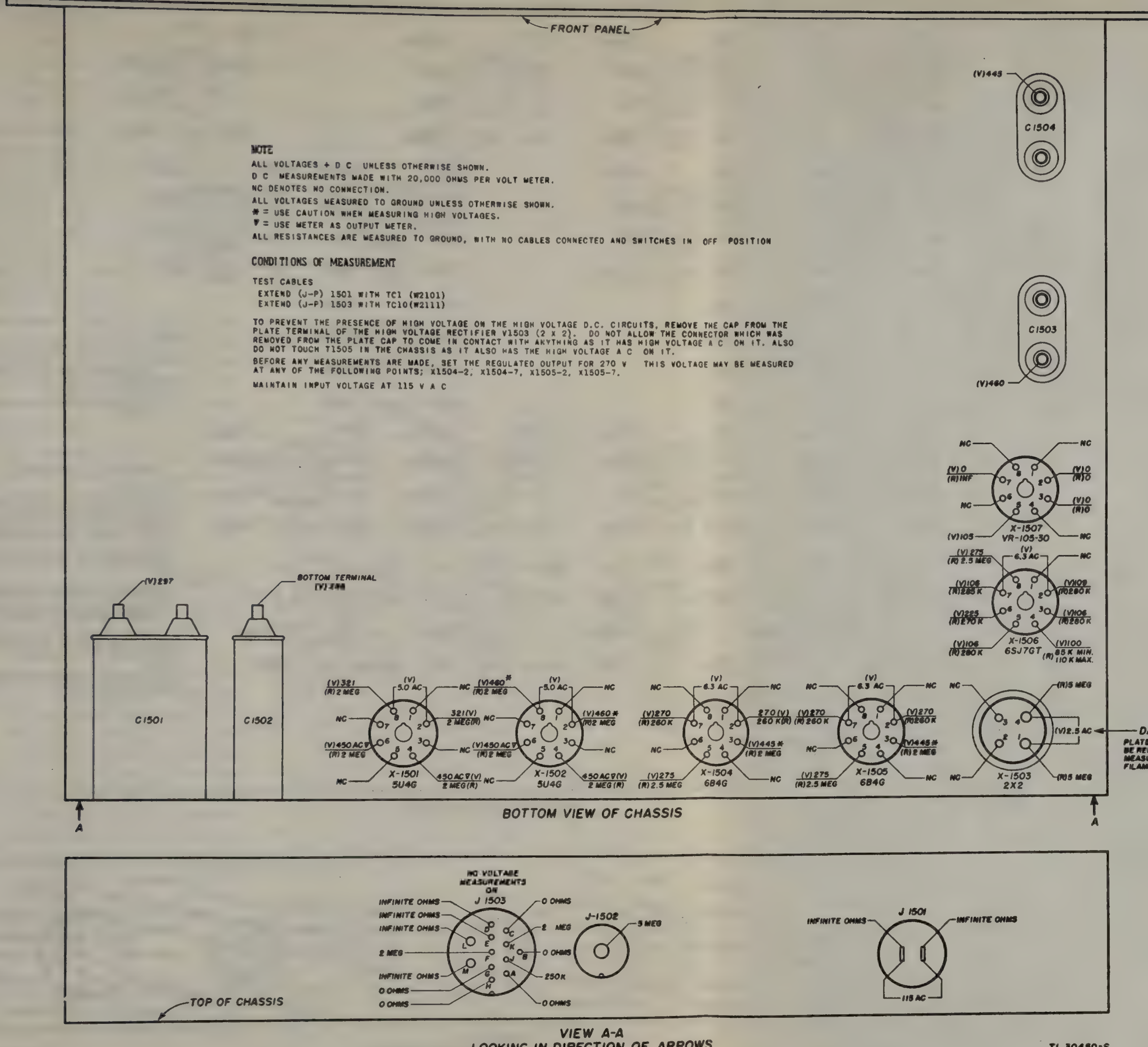


Figure 323. PPI power supply, voltage and resistance chart.

Figure 323. PPI power supply, voltage and resistance chart.

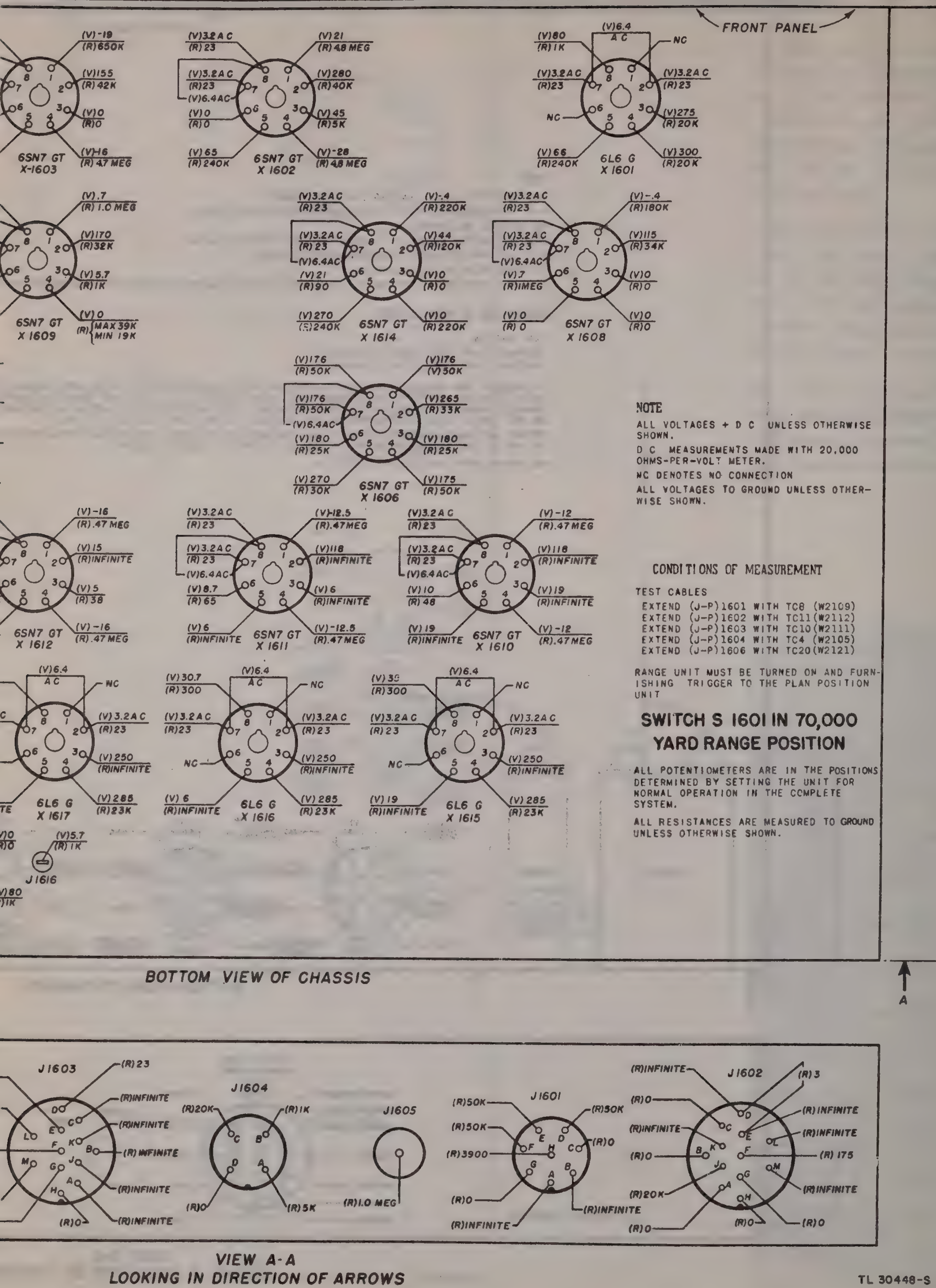


Figure 324. PPI unit, voltage and resistance chart.

of the PPI unit. If sufficient centering control is not available, the position of the focus coil in the PPI indicator must be adjusted by means of the adjusting screws provided.

e. Range Marker Control. Set the INTENSITY control so that the PPI sweep may be plainly seen. Adjust the RANGE MARKER control on the PPI unit chassis so that the range markers can be plainly seen as bright spots on the PPI sweep. The intensity of the range markers should increase with clockwise rotation of the RANGE MARKER control. The range markers are 10,000 yards apart.

f. Narrow Gate Control. Set the range on the range indicator unit at about 15,000 yards. Adjust the NARROW GATE control on the PPI unit chassis so that the narrow gate is plainly visible as a brightened dash on the PPI sweep.

g. Sweep Adjust Controls.

(*1*) Adjust the 35,000-YD SWEEP control on the PPI unit chassis so that the length of the PPI sweep shown on the face of the PPI scope is 37,000 to 40,000 yards. (The range markers are 10,000 yards apart.)

(*2*) Turn the RANGE SWITCH to the 70,000-yard position. Adjust the 70,000-YD SWEEP control in the PPI unit chassis so that the length of the PPI sweep shown on the face of the PPI scope is 75,000 yards.

h. Circle Adjust Controls. Turn the control switch on the indicator-control panel to the PPI SCAN position. The parabola will rotate clockwise, and the PPI sweep should also rotate clockwise. The circularity of the rings made by the range markers, as they rotate about the center of the PPI scope, should be adjusted by means of the two CIRCLE ADJUST controls on the chassis of the PPI unit, so that the lines left by the range markers make concentric circles about the center of the PPI scope. Under some conditions, it may not be possible to obtain perfect circles. The allowable departure from a circle is 10 percent of the radius.

i. Final Checks.

(*1*) Make a final focus adjustment of the PPI sweep while the sweep is rotating. It should be possible to obtain a line not wider than 1/32 inch. Lock all controls.

(*2*) Check the range markers by setting the narrow gate at 10,000, 20,000, and 30,000 yards. The narrow gate marker should straddle the range markers at each of the above settings within 10 percent of the range to each setting.

290. ADJUSTMENT OF DEFLECTION COIL.

The deflection coil does not normally require adjustments when a PPI tube is replaced unless the shape of the replacement tube is such that the deflection coil must be moved toward the socket end of the tube in order to allow replacement of the front ring. If adjustment becomes necessary, as indicated by the outer portion of parts of the sweep having low brilliance and poor focus, proceed as follows:

> **CAUTION:** Do not make the following adjustments while the power is on.

a. The focus coil must be adjusted so that the spot is within ¼ inch of the center and the centering controls adjusted so that the spot is centered. If the focus coil requires adjustment, see paragraph 291.

b. Loosen the two side adjusting screws (fig. 326) of the deflection coil and partially loosen the bottom adjusting screw. Adjust the coil by moving from right to left or left to right so that when the power is turned on and the CONTROL SWITCH in the indicator-control panel is on PPI SCAN, the sweep has the greatest uniformity of intensity over the entire rotation.

c. Tighten the two side adjusting screws partially and loosen the bottom adjusting screw (fig. 326). Move the bottom of the coil toward the socket of the tube or toward the screen of the tube, whichever results in the best over-all appearance of the PPI sweep. Tighten the three adjusting screws.

d. If necessary, repeat the adjustments **b** and **c** until satisfactory uniformity in the sweep intensity exists over the entire area of the scope screen.

291. ADJUSTMENT OF FOCUS COIL.

The focus coil is mounted by means of three adjusting screws (fig. 326), two of these being located on the sides and the third on the bottom of the shield. To focus the beam properly it is necessary to position the coil so that the axis of the coil lines up with the axis of the PPI tube. If, when the voltage across the horizontal and vertical deflecting coils is zero, the spot is not within ¼ inch of the dot in the center of the screen face, the focus coils must be adjusted.

Figure 324. PPI unit, voltage and resistance chart.

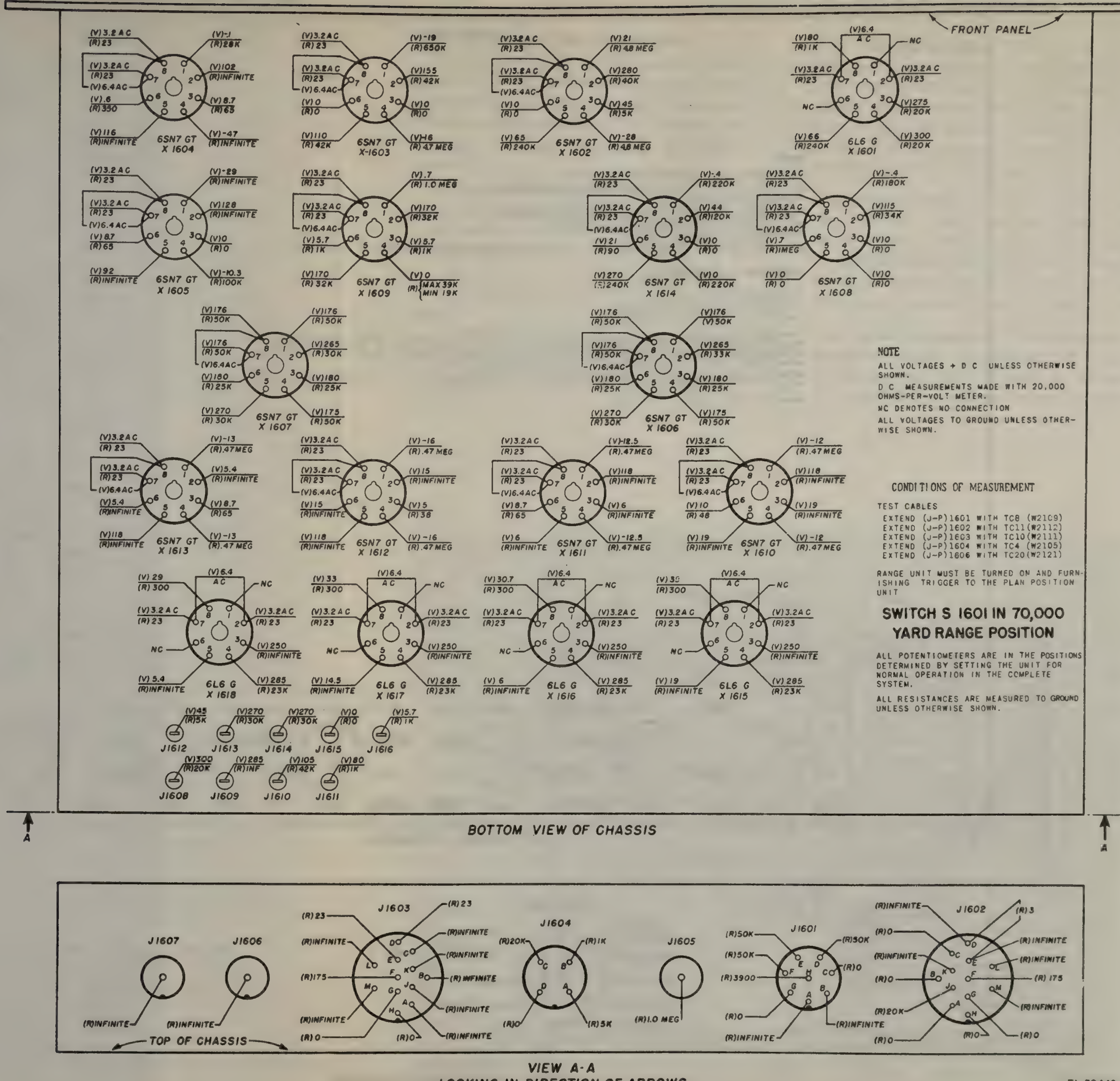


Figure 324. PPI unit, voltage and resistance chart.

of the PPI unit. If sufficient centering control is not available, the position of the focus coil in the PPI indicator must be adjusted by means of the adjusting screws provided.

e. Range Marker Control. Set the INTENSITY control so that the PPI sweep may be plainly seen. Adjust the RANGE MARKER control on the PPI unit chassis so that the range markers can be plainly seen as bright spots on the PPI sweep. The intensity of the range markers should increase with clockwise rotation of the RANGE MARKER control. The range markers are 10,000 yards apart.

f. Narrow Gate Control. Set the range on the range indicator unit at about 15,000 yards. Adjust the NARROW GATE control on the PPI unit chassis so that the narrow gate is plainly visible as a brightened dash on the PPI sweep.

g. Sweep Adjust Controls.

(*1*) Adjust the 35,000-YD SWEEP control on the PPI unit chassis so that the length of the PPI sweep shown on the face of the PPI scope is 37,000 to 40,000 yards. (The range markers are 10,000 yards apart.)

(*2*) Turn the RANGE SWITCH to the 70,000-yard position. Adjust the 70,000-YD SWEEP control in the PPI unit chassis so that the length of the PPI sweep shown on the face of the PPI scope is 75,000 yards.

h. Circle Adjust Controls. Turn the control switch on the indicator-control panel to the PPI SCAN position. The parabola will rotate clockwise, and the PPI sweep should also rotate clockwise. The circularity of the rings made by the range markers, as they rotate about the center of the PPI scope, should be adjusted by means of the two CIRCLE ADJUST controls on the chassis of the PPI unit, so that the lines left by the range markers make concentric circles about the center of the PPI scope. Under some conditions, it may not be possible to obtain perfect circles. The allowable departure from a circle is 10 percent of the radius.

i. Final Checks.

(*1*) Make a final focus adjustment of the PPI sweep while the sweep is rotating. It should be possible to obtain a line not wider than 1/32 inch. Lock all controls.

(*2*) Check the range markers by setting the narrow gate at 10,000, 20,000, and 30,000 yards. The narrow gate marker should straddle the range markers at each of the above settings within 10 percent of the range to each setting.

290. ADJUSTMENT OF DEFLECTION COIL.

The deflection coil does not normally require adjustments when a PPI tube is replaced unless the shape of the replacement tube is such that the deflection coil must be moved toward the socket end of the tube in order to allow replacement of the front ring. If adjustment becomes necessary, as indicated by the outer portion of parts of the sweep having low brilliance and poor focus, proceed as follows:

> **CAUTION:** Do not make the following adjustments while the power is on.

a. The focus coil must be adjusted so that the spot is within ¼ inch of the center and the centering controls adjusted so that the spot is centered. If the focus coil requires adjustment, see paragraph 291.

b. Loosen the two side adjusting screws (fig. 326) of the deflection coil and partially loosen the bottom adjusting screw. Adjust the coil by moving from right to left or left to right so that when the power is turned on and the CONTROL SWITCH in the indicator-control panel is on PPI SCAN, the sweep has the greatest uniformity of intensity over the entire rotation.

c. Tighten the two side adjusting screws partially and loosen the bottom adjusting screw (fig. 326). Move the bottom of the coil toward the socket of the tube or toward the screen of the tube, whichever results in the best over-all appearance of the PPI sweep. Tighten the three adjusting screws.

d. If necessary, repeat the adjustments **b** and **c** until satisfactory uniformity in the sweep intensity exists over the entire area of the scope screen.

291. ADJUSTMENT OF FOCUS COIL.

The focus coil is mounted by means of three adjusting screws (fig. 326), two of these being located on the sides and the third on the bottom of the shield. To focus the beam properly it is necessary to position the coil so that the axis of the coil lines up with the axis of the PPI tube. If, when the voltage across the horizontal and vertical deflecting coils is zero, the spot is not within ¼ inch of the dot in the center of the screen face, the focus coils must be adjusted.

CAUTION: High voltage is present. Extreme care must be exercised to avoid coming in contact with the 45,000-volt supply to the second anode of the PPI tube. While a mechanical adjustment is being made, the power must be turned off. After the adjustment is made, turn on the power and observe the effect of the adjustment. This procedure of turning the power off, making the necessary adjustment, and turning the power on again to note the effect of the adjustment, must be repeated until the desired performance is obtained.

a. Adjust the centering controls so that the voltage across the plates of each pair of the deflection tubes is zero.

b. Loosen the two side adjusting screws which hold the focus coil. Slightly loosen the bottom adjusting screws.

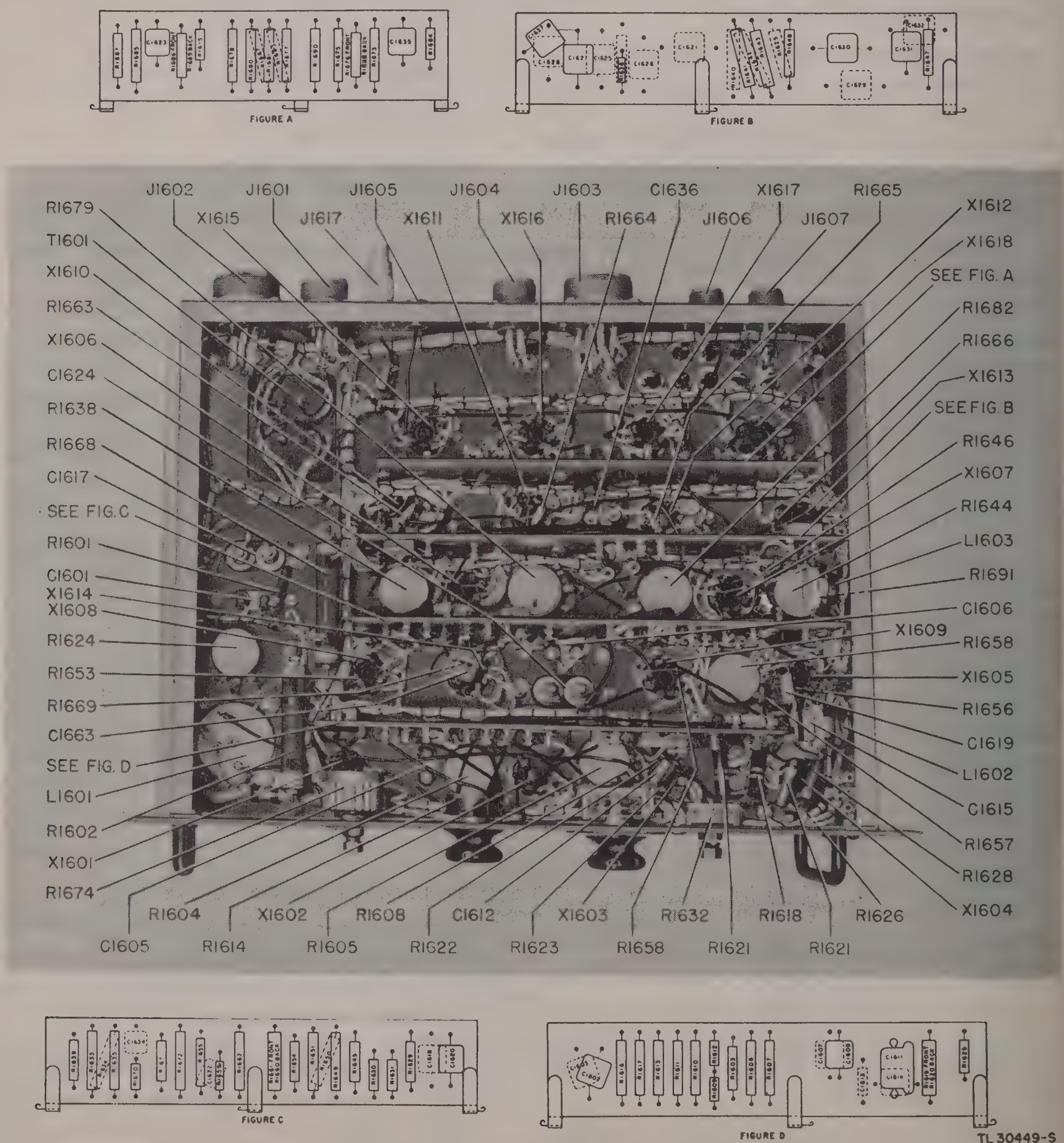


Figure 325. PPI unit, bottom view, parts identified.

c. Move the coil from left to right or right to left, pivoting about the bottom adjusting screw so that the spot is as close as possible to the center.

d. Tighten the two side adjusting screws partially and loosen the bottom adjusting screw. Move the bottom of the coil toward the socket or screen of the PPI tube so as to position the spot within ¼ inch of the center of the tube.

e. If necessary, repeat the adjustments **b** to **d.** Tighten the adjusting screws.

292. REPLACEMENT OF THE PPI TUBE.

The PPI tube may be replaced easily if extreme care is taken for the protection of personnel as well as the equipment. Goggles and gloves must be worn to protect the hands and eyes in case the tube bursts. Use figure 326 as a reference for the disassembly. The procedure for disassembly is as follows:

a. Remove the plate at the rear of the PPI shield by taking off the thumbscrew.

b. Remove the tube socket from the tube. Do not jar the tube or apply too much pressure on it. Hold the tube base while removing the socket.

c. Remove the three screws which fasten the bezel to the front panel and pull off the bezel.

d. Remove the second anode high-voltage connection and then pull the tube out of its position. Take extreme care in handling the tube.

e. It is unnecessary to remove the focus or deflection coil to install a new tube. However, it may be necessary to slide the deflection coil further toward the base of the socket if the new tube is so shaped that it is impossible to replace the front ring and scale assembly. The focus or deflection coils can be removed by removing the screws holding them to the mounting brackets. These screws are actually the adjusting screws.

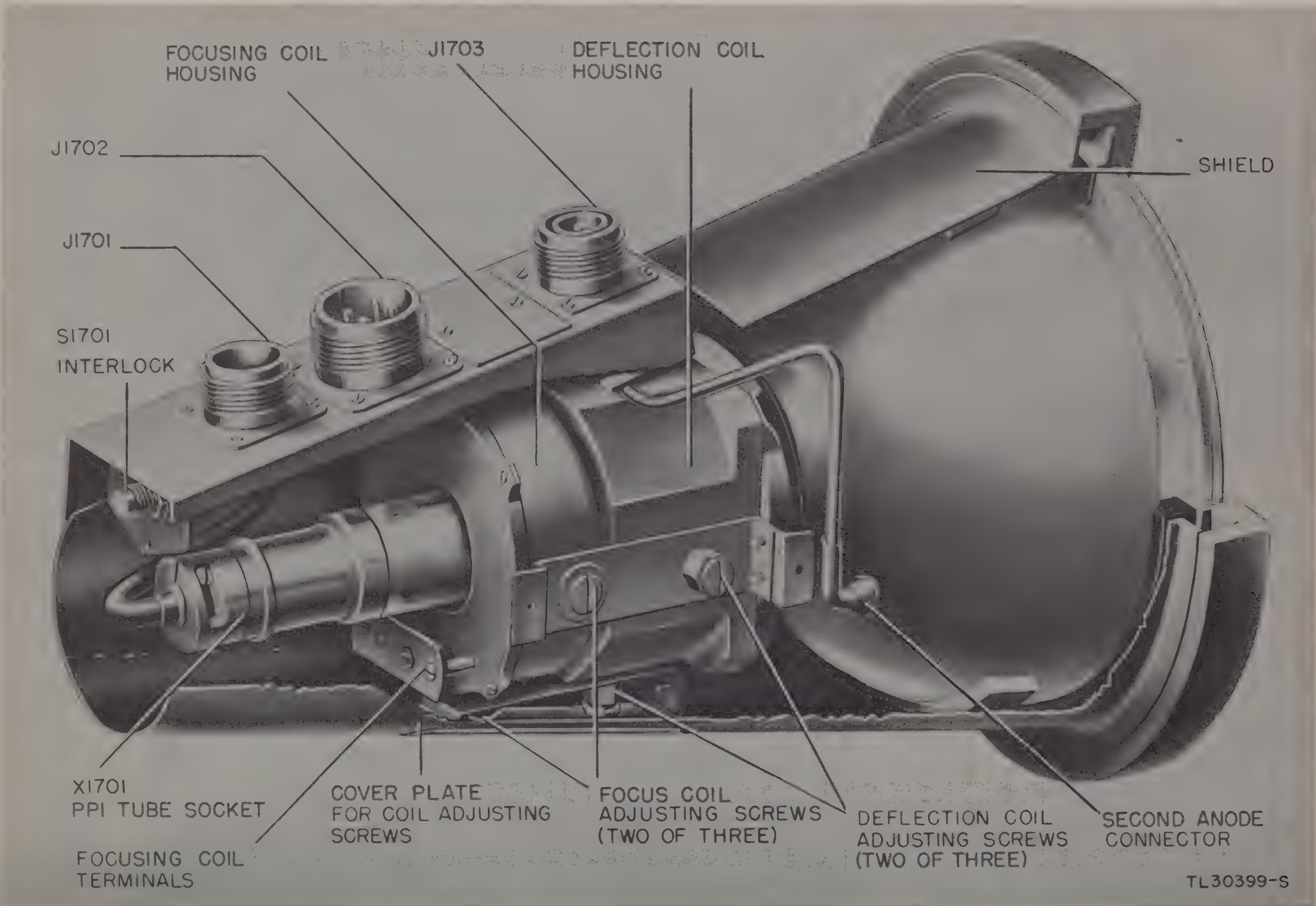
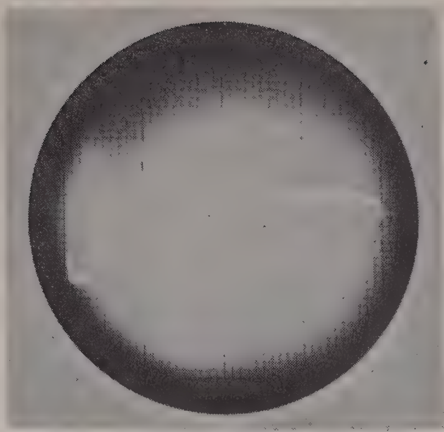


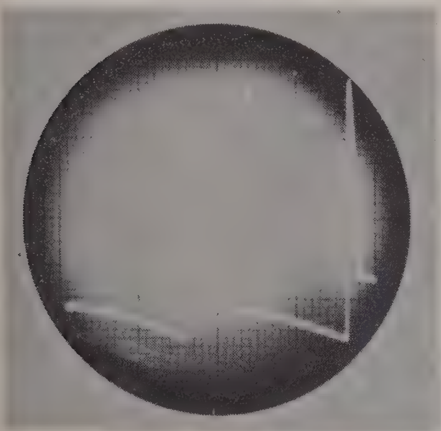
Figure 326. PPI assembly, cutaway view.

Multivibrator, V1603
Range 70,000-yd
Test point, J1610
Scope sensitivity, 100 volts/inch

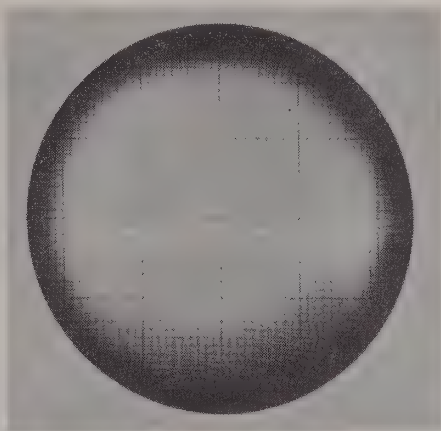


Sweep Intensifier V1602A
Range 70,000-yd
Test point, J1612
Scope sensitivity, 25 volts/inch

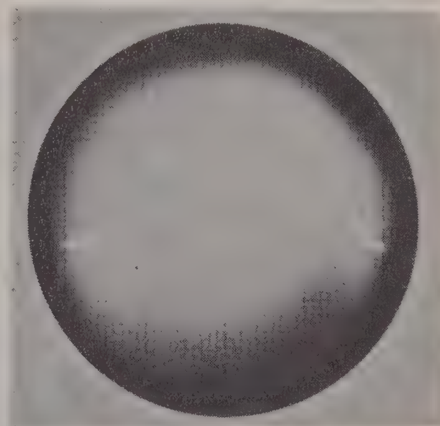
Selsyn Driver, V1601
Range 70,000-yd
Test point, J1611
Scope sensitivity, 100 volts/inch



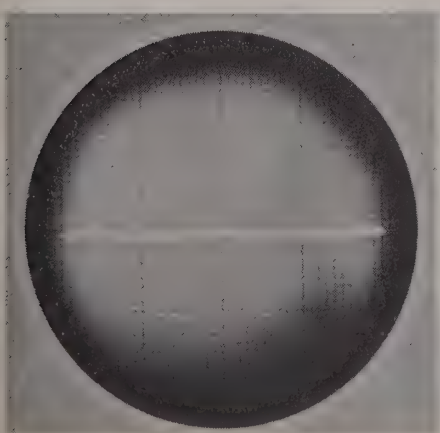
Selsyn Driver, V1601
Range 70,000-yd
Test point, plate 3
Scope sensitivity, 25 volts/inches



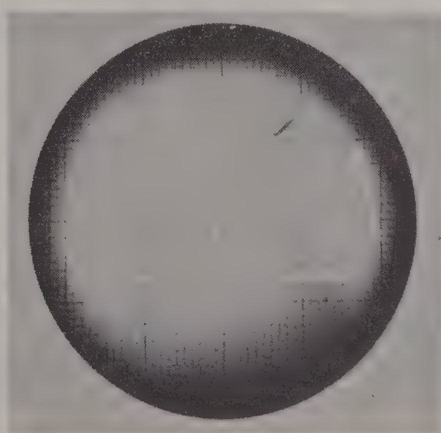
Horizontal Amp Inverter V1606, or Vertical Amp Inverter V1607
Range 70,000-yd
Test point, grid 4, V1606
grid 1, V1607
Scope sensitivity, 25 volts/inch



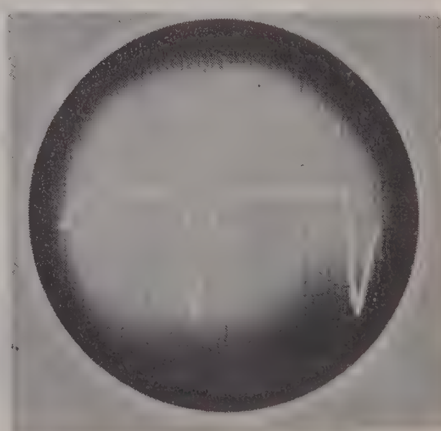
Horizontal Amplifier Inverter V1606
Range 70,000-yd
Test point, J1613
Scope sensitivity, 25 volts/inch
Maximum positive



Vertical Amplifier Inverter V1607
Range 70,000-yd
Test point, J1614
Scope sensitivity, 25 volts/inch
With J1613 maximum



Horizontal Amplifier V1616
Range 70,000-yd
Test point, plate 3
Scope sensitivity, 25 volts/inch
Maximum positive



Vertical Amplifier V1617
Range 70,000-yd
Test point, plate 3
Scope sensitivity, 25 volts/inch
Maximum negative

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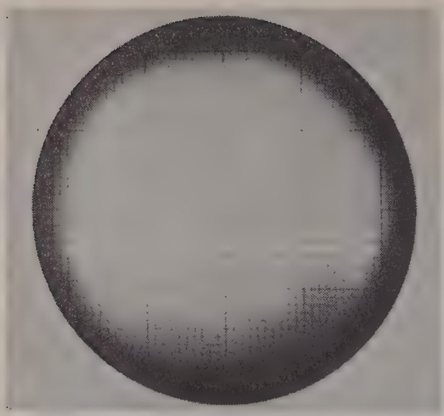
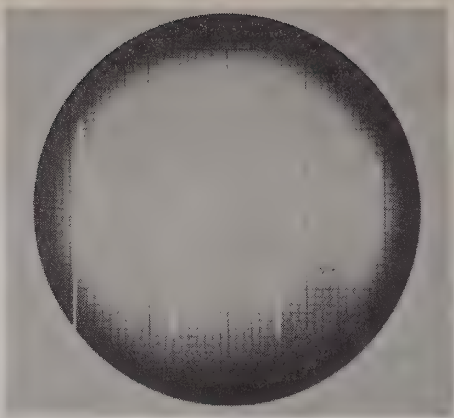
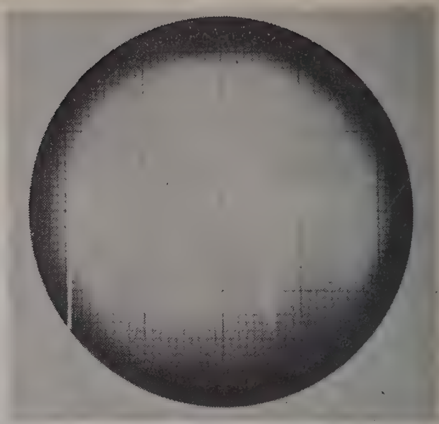
Figure 327. PPI unit, test waveforms, 70,000-yd range.



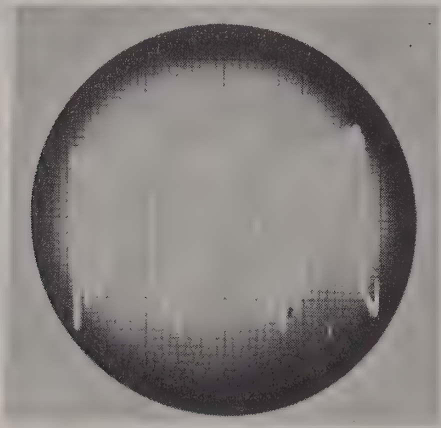
Horizontal Amplifier V1616
Range 70,000-yd
Test point, plate 3
Scope sensitivity, 25 volts/inch
With plate of V1617 maximum



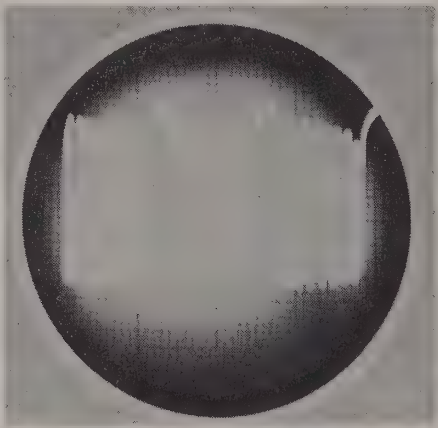
Range Marker Osc V1604B
Range 70,000-yd
Test point, cathode 6
Scope sensitivity, 25 volts/inch



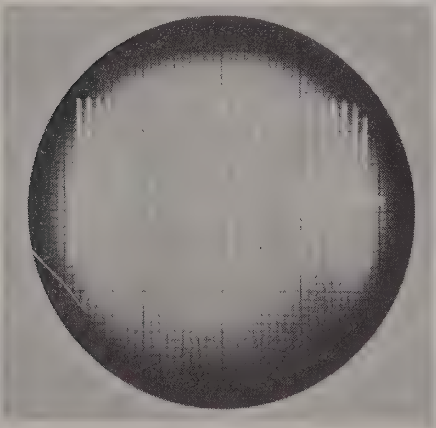
Clipper V1604B
Range 70,000-yd
Test point, grid 1
Scope sensitivity, 25 volts/inch



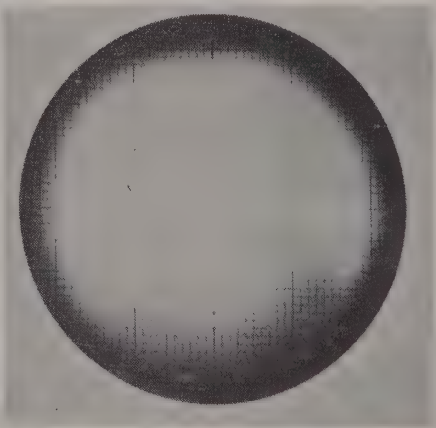
Clipper V1604B
Range 70,000-yd
Test point, plate 2
Scope sensitivity, 25 volts/inch



Clipper V1605B
Range 70,000-yd
Test point, plate 5
Scope sensitivity, 25 volts/inch



Range Marker Generator V1605A
Range 70,000-yd
Test point, plate 2
Scope sensitivity, 25 volts/inch



Signal Mixer V1609AB
Range 70,000-yd
Test point, cathodes 3-6, J1616
Scope sensitivity, 25 volts/inch

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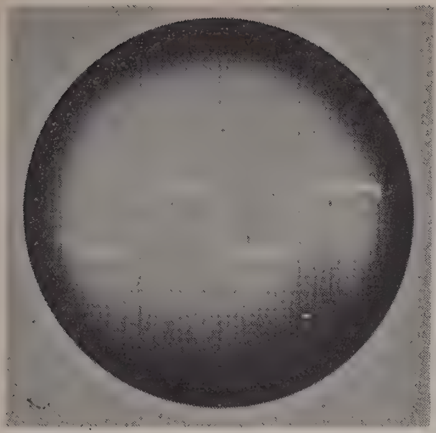
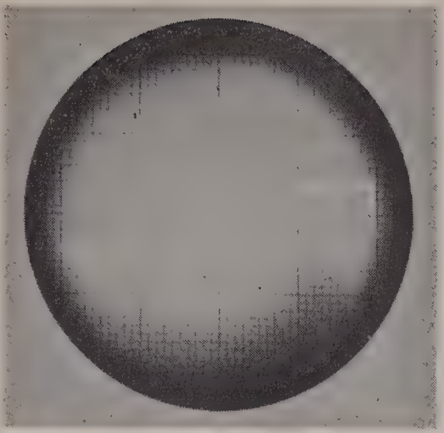
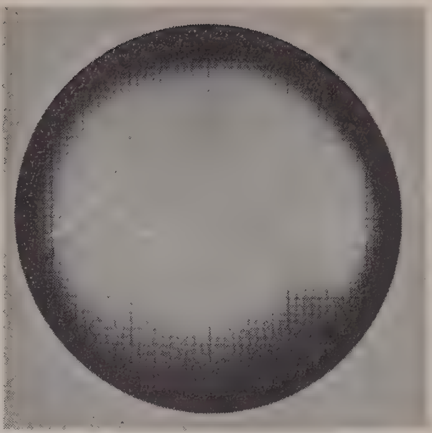
Figure 327a. PPI unit, test waveforms, 70,000-yd range.



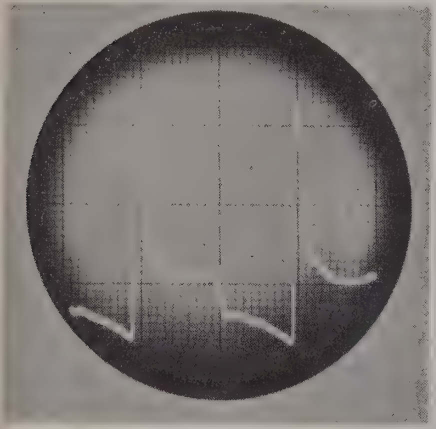
Multivibrator, V1603
Range 35,000-yd
Test point, J1610
Scope sensitivity, 100 volts/inch



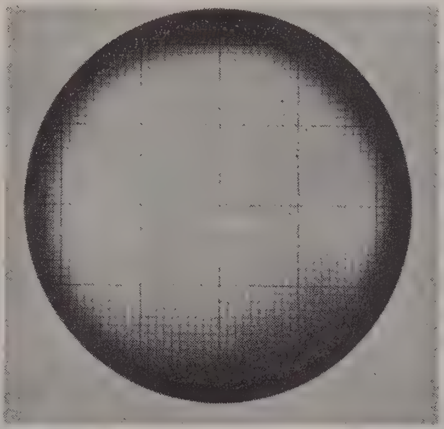
Sweep Intensifier V1602A
Range 35,000-yd
Test point, J1612
Scope sensitivity, 25 volts/inch



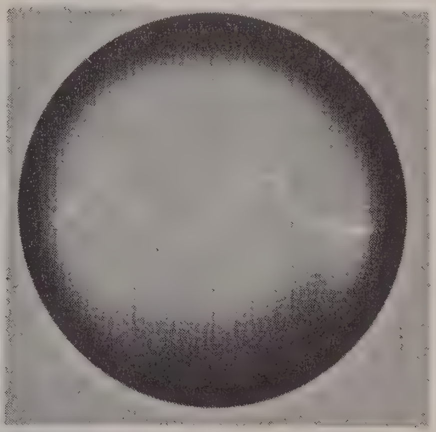
Selsyn Driver V1601
Range 35,000-yd
Test point, J1611
Scope sensitivity, 100 volts/inch



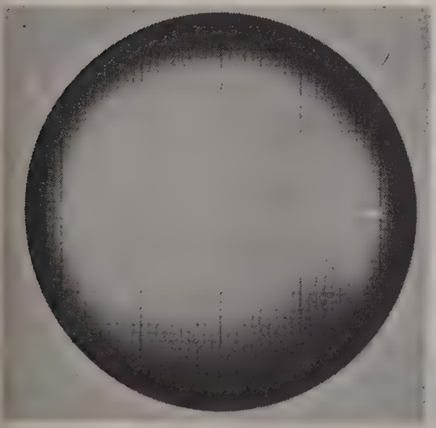
Selsyn Driver V601
Range 35,000-yd
Test point, plate 3
Scope sensitivity, 25 volts/inch



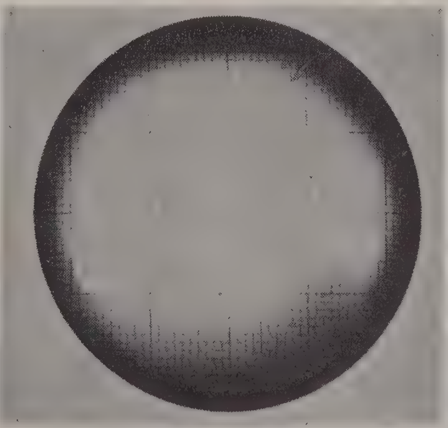
Horizontal Amp Inverter V1606, or Vertical Amp Inverter V1607
Range 35,000-yd
Test point, grid 4, V1606
grid 1, V1607
Scope sensitivity, 25 volts/inch



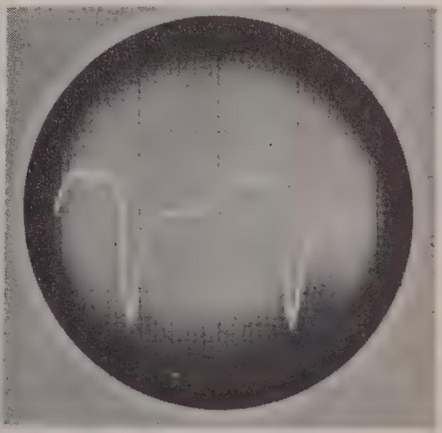
Horizontal Amplifier Inverter V1606
Range 35,000-yd
Test point, J1613
Scope sensitivity, 25 volts/inch
Maximum positive



Vertical Amplifier Inverter V1607
Range 35,000-yd
Test point, J1614
Scope sensitivity, 25 volts/inch
With J1613 maximum



Horizontal Amplifier V1616
Range 35,000-yd
Test point, plate 3
Scope sensitivity, 25 volts/inch
Maximum positive



Vertical Amplifier V1617
Range 35,000-yd
Test point, plate 3
Scope sensitivity, 25 volts/inch
Maximum negative

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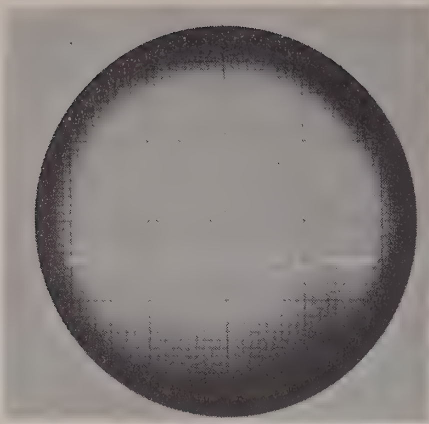
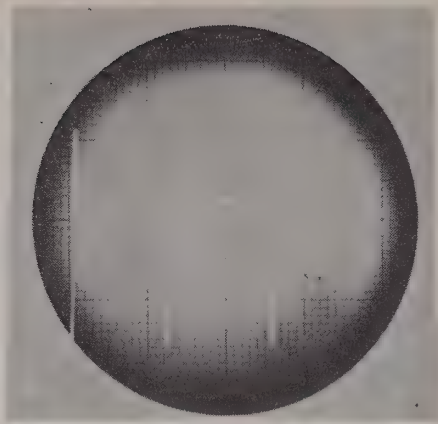
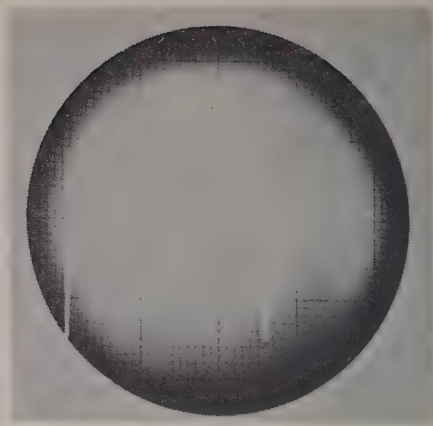
Figure 328. PPI unit, test waveforms, 35,000-yd range.



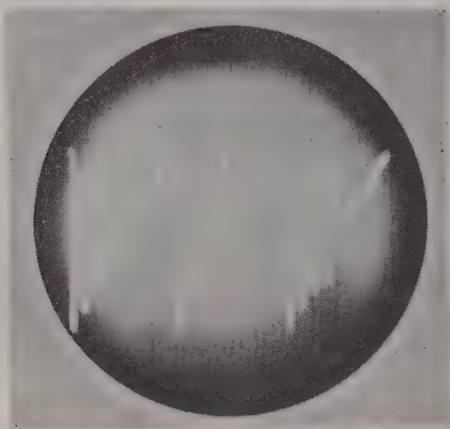
Horizontal Amplifier V1616
Range 35,000-yd
Test point, plate 3
Scope sensitivity, 25 volts/inch
With plate of V1617 maximum



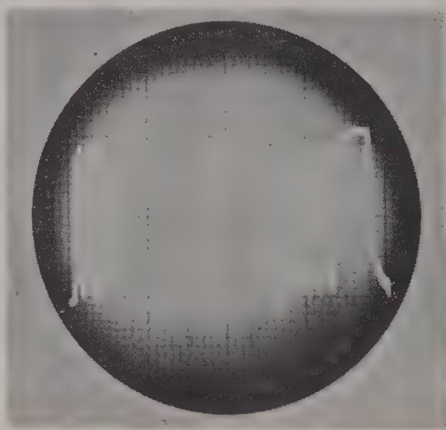
Range Marker Osc V1604B
Range 35,000-yd
Test point, cathode 6
Scope sensitivity, 25 volts/inch



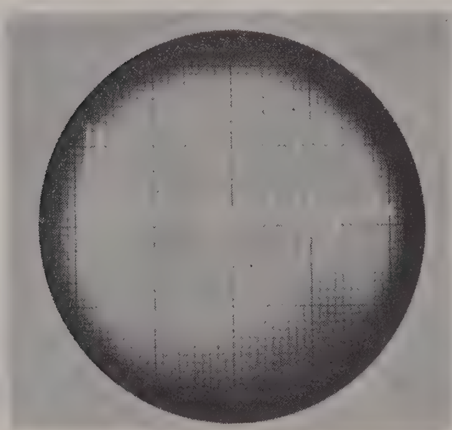
Clipper V1604B
Range 35,000-yd
Test point, grid 1
Scope sensitivity, 25 volts/inch



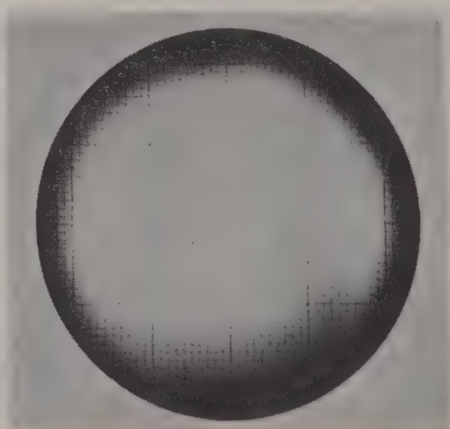
Clipper V1604B
Range 35,000-yd
Test point, plate 2
Scope sensitivity, 25 volts/inch



Clipper V1605B
Range 35,000-yd
Test point, plate 5
Scope sensitivity, 25 volts/inch



Range Marker Generator V1605A
Range 35,000-yd
Test point, plate 2
Scope sensitivity, 25 volts/inch



Signal Mixer V1609
Range 35,000-yd
Test point, cathodes 3-6, J1616
Scope sensitivity, 25 volts/inch

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Figure 328a. PPI unit, test waveforms, 35,000-yd range.

CHAPTER 18

TROUBLE SHOOTING IN THE ANTENNA POSITIONING SYSTEM

293. REFERENCE DATA.

Reference to the following figures will assist maintenance personnel in trouble shooting in the antenna positioning system.

a. Block Diagrams.

(*1*) Figure 178, Antenna positioning system, complete block diagram.

(*2*) Figure 182, Automatic tracking system, block diagram.

(*3*) Figure 183, Manual positioning system, block diagram.

b. Automatic Tracking Unit.

(*1*) Figure 186, Automatic tracking unit, top view, parts identified.

(*2*) Figure 212, Automatic tracking unit, complete schematic diagram.

(*3*) Figure 329, Automatic tracking unit, bottom view, parts identified.

(*4*) Figure 339, Automatic tracking unit, voltage and resistance chart.

c. Azimuth and Elevation Tracking Unit.

(*1*) Figure 193, Azimuth and elevation tracking unit, top view, parts identified.

(*2*) Figure 213, Azimuth and elevation tracking unit, complete schematic diagram.

(*3*) Figure 330, Azimuth and elevation tracking unit, bottom view, parts identified.

(*4*) Figure 340, Azimuth and elevation tracking unit, voltage and resistance chart.

d. Antenna Position Control Unit.

(*1*) Figure 207, Antenna position control unit, top view, parts identified.

(*2*) Figure 210, Antenna position control unit, gearing diagram.

(*3*) Figure 215, Antenna position control unit, schematic diagram.

(*4*) Figure 331, Antenna position control unit, bottom view, parts identified.

(*5*) Figure 332, Antenna position control unit, voltage and resistance chart.

e. Antenna Position Indicator Unit.

(*1*) Figure 214, Antenna position indicator unit, complete schematic diagram.

(*2*) Figure 334, Antenna position indicator unit, rear view, parts identified.

(*3*) Figure 333, Antenna position indicator unit, bottom view, parts identified.

(*4*) Figure 342, Antenna position indicator unit, voltage and resistance chart.

f. Indicator-control Panel.

(*1*) Figure 30, Indicator-control panel, complete schematic diagram.

(*2*) Figure 202, Indicator-control panel, front view.

(*3*) Figure 335, Indicator-control panel, bottom view, parts identified.

(*4*) Figure 336, Indicator-control panel, voltage and resistance chart.

g. Servo Motor-generator.

(*1*) Figure 204, Servo motor-generator, schematic diagram.

(*2*) Figure 337, Servo motor-generator, parts identified.

h. Field Power Supply.

(*1*) Figure 205, Field power supply, schematic diagram.

(*2*) Figure 338, Field power supply, bottom view, parts identified.

(*3*) Figure 341, Field power supply, voltage and resistance chart.

i. Cabling Diagram.

(*1*) Figure 184, Antenna positioning system, cabling diagram.

(*2*) Figure 259, Interconnecting cables, wiring diagram.

(*3*) Figure 260, Control circuits, schematic diagram.

j. Miscellaneous.

(*1*) Figure 191, Safety relay interlock circuit, schematic diagram.

(*2*) Figure 208, Selsyn control system.

(*3*) Figure 209, Connections to relays for manual positioning.

(*4*) Figure 201, Elevation limit switches, schematic diagram.

294. GENERAL TROUBLE ANALYSIS.

The antenna positioning system is composed of the antenna position indicator unit, the antenna position control unit, the automatic tracking unit, the azimuth and elevation tracking unit, the indicator-control panel, the azimuth and elevation servo generators, the field power supply, the azimuth and elevation drive motors, the spinner motor and reference generator connected to the antenna, and the azimuth and elevation selsyn transformers in the pedestal. The first step in trouble shooting the system is to try to sectionalize the trouble. Do not replace tubes unless the tubes test bad. When a trouble in the antenna positioning system cannot be located by use of the trouble-shooting chart, the next step is to align the system as outlined in paragraph 296. The following general steps help to sectionalize a trouble.

a. Automatic Tracking Unit.

(*1*) Improper automatic operation but normal manual positioning of the antenna indicates a fault in the signal circuits of the automatic tracking unit. Check to see that the PLATE CURRENT meter indicates current. Lack of a meter reading indicates a fault in the error signal detector or amplifier stages. Check to see that coast relay K501 is not locked in.

(*2*) Improper automatic and manual operation may be due to trouble in the safety relay circuit or trouble in the power supply section of the automatic tracking unit. These failures can be detected by visual inspection. Relay K502 should be firmly closed for proper operation of the safety relay circuit. Failure of the power supply can be detected by the meters on the automatic tracking unit and the azimuth and elevation tracking unit, and by checking for 75 volts at jack J506.

(*3*) When the antenna cannot be positioned by any of the four positioning methods, check to see that the SAFETY switch on the indicator-control panel is set to the RUN position and that relay K502 in the automatic tracking unit is closed. This relay circuit must be closed before any other attempts are made to locate the trouble. Check to see that the servo motor-generators are operating.

b. Azimuth and Elevation Tracking Unit. The azimuth and elevation tracking unit is the heart of the antenna positioning system. Evidence of difficulty in the azimuth and elevation tracking unit usually show up in abnormal operation in azimuth or elevation positioning, but not in both.

(*1*) *Antenna Cannot Be Positioned in Azimuth.* When the antenna cannot be positioned in azimuth but can be positioned in elevation; the trouble is in the azimuth channel of the azimuth and elevation tracking unit.

(*a*) Check to see that the FIELD CURRENT meters show a reading when the switch beneath the meters is in the AZIMUTH position. Lack of meter readings indicates the trouble is in the d-c amplifiers circuit. Since the field windings of the motor generator are in the plate circuit of the d-c amplifiers, the trouble may be in the field windings of the exciter in the azimuth servo.

(*b*) Check to see if the system operates with the CONTROL SWITCH in other positions. Proper operation in AUTOMATIC, but not in PPI SCAN or MANUAL indicates trouble in the antenna position control unit, the selsyn transformer, or the local-remote relays.

(*2*) *Antenna Cannot Be Positioned in Elevation.* When the antenna cannot be positioned in elevation but can be positioned in azimuth; the trouble is in the elevation channel and is similar to the trouble in subparagraph (*1*) above.

c. Antenna Position Control Unit. If the gearing is oiled occasionally and the unit kept clean, very little trouble is experienced in the antenna position control unit. Lubrication is covered in TM 11-1454, Preventive Maintenance Manual. The greatest amount of trouble occurs in the electrical connections and electrical apparatus. Most of the electrical troubles may be found by making continuity and resistance checks. If one of the handwheels does not turn freely, inspect the gears for dirt and jamming. If a control selsyn is sticking or does not turn freely, and the fault is not eliminated by cleaning and lubricat-

ing, replace the selsyn. Outlines of the procedures to replace a control selsyn, the PPI scan motor, or a follow-up motor are given in paragraph 297.

d. Antenna Position Indicator Unit. The antenna position indicator unit, in addition to its normal functions of indicating the position of the antenna, is one of the most important interconnection points in the antenna positioning system. Many faults may occur here which show up as symptoms in positioning the antenna. Most of these faults can be detected by continuity checks of the wiring and by observing the behavior of the index pointer. The local azimuth index and local elevation index should follow the motion of the reflector at all times. The remote azimuth index and the remote elevation index should follow the movement of the gun director telescopes at all times. Because this unit is allied closely with the data transmission system, the symptoms concerning the behavior of the index dials are covered in the data transmission system trouble-shooting chart. The dial lights should light when the MAIN LINE switch is thrown to the ON position. If none of the dial lights are lit, check fuses F1905 and F1906. If only a few dial lights are not lit, replace the defective bulbs. Outlines of the procedures for replacing a bulb, a local receiving selsyn, and a remote receiving selsyn are given in paragraph 298.

e. Indicator-control Panel. The indicator-control panel provides the controls for the relays in the various units to select the type of operation desired. Certain failures in the indicator-control panel seem to indicate failure of the other units. Most of the troubles which may appear in the indicator-control panel may be located by continuity checks with the aid of figure 260. The operation of the relays may be observed when the CONTROL SWITCH is thrown. The voltages which should exist at the various points on the components of the control panel are indicated in figure 336 for each of the four positions of the control switch. If the antenna cannot be moved out of an upper or a lower position, check to see that the copper-oxide rectifier on the switch and data panel is not grounded.

f. Servo Motor-generators. Troubles in the servo motor-generators may, in most instances, be located from the azimuth and elevation tracking unit. To check the operation of a motor generator, observe the reading of the FIELD CURRENT meters and then measure the output voltage at terminals C-1 and C-4 or on the terminal block of the servo generator. Checks for continuity of the field windings and armature indicate whether there are open wires. Resistance measurements to the frame of the servo generator indicate if there are grounded windings. There should be no grounded connections on these units. Repairs other than a broken lead should not be attempted except by depot personnel or personnel experienced in the repair of motors and generators. General maintenance information concerning the care of the commutators and lubrication of the servo generators is given in Technical Manual TM 11-1454.

g. Field Power Supply. The most likely sources of trouble in the field power supply are the fuses and the tube. In either case there would be no output and this would result in no antenna movement. Under full load, the voltage between pins B and C on jack J1153 should be 300 volts with pin B positive. This voltage increases considerably when the load is removed. If the load on the power supply seems to be too great, check the cable to J1153 for a short. Where possible, voltage tests should be made with a suitable dummy load connected. No filter capacitors are used in the power supply circuit, and troubles other than a fuse or a tube can usually be located by voltage checks.

295. CONTROL SETTINGS.

The trouble symptoms and the trouble-shooting procedures outlined in the following trouble-shooting chart are concerned only with actual troubles in the system, and are not concerned with improper switch and control settings. These settings should be checked before any trouble-shooting procedure is begun because a deviation from these settings may produce a symptom which appears to be a trouble.

a. On Switch and Data Panel:

(*1*) SPINNER MOTOR switch set to ON position.

(*2*) AZIMUTH MOTOR switch set to ON position.

(*3*) ELEVATION MOTOR switch set to ON position.

b. On Indicator-control Panel:

(*1*) SAFETY SWITCH set to RUN position.

(*2*) CONTROL SWITCH set to desired method of antenna positioning.

c. On Automatic Tracking Unit:

(*1*) Power ON-OFF switch set to ON position.

(*2*) BALANCE control set so that voltage checked at COMMUTATOR INPUT J504 is equal to voltage at COMMUTATOR INPUT J505 with no targets in the narrow or N^2 gate.

(*3*) VOLTAGE CONTROL set so that voltage checked at jack J510 reads 2.9 volts.

(*4*) AVC control set so that PLATE CURRENT meter reads 6 milliamperes with antenna directed at a fixed target and CONTROL SWITCH set to AUTOMATIC position.

(*5*) GAIN control set so that antenna is not sluggish in operation.

d. On Azimuth and Elevation Tracking Unit:

(*1*) AH LIMITING CONTROL set to obtain 8 to 9 volts between jacks J411 and J413 (J411 being positive).

(*2*) TORQUE CONTROL set to obtain 3 to 4 volts between jacks J413 and J414 (J414 being positive).

(*3*) CURRENT CONTROL set to obtain 25 milliampere reading on both FIELD CURRENT meters with the meter key switch in each of its AZIMUTH and ELEVATION positions.

(*4*) AH GAIN control set so that antenna does not hunt in operation.

(*5*) BALANCE controls set to eliminate drifting of antenna.

296. ANTENNA POSITIONING SYSTEM, TROUBLE-SHOOTING CHART.

A. SYMPTOM: Faulty operation in azimuth and elevation with the CONTROL SWITCH in any position.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Automatic tracking unit power supply.	1*a*. Check to see if the red pilot light on the automatic tracking unit is lit and the PLATE CURRENT meter indicates current. If not: (*1*) Replace fuses F501 and F502. If these fuses blow, check capacitors C505 and C506 to see if either is shorted. (*2*) Replace pilot light I501. If it does not light refer to figure 260 and check for continuity of the a-c input circuit to the automatic tracking unit. *b*. If the red pilot light burns: (*1*) Check for +75 volts at J506. (*2*) Test tube V501. Replace if defective. *c*. Make voltage and resistance checks at the sockets of V501 and V505 (fig. 339).
2. Defective manual-automatic relays.	2. Check relays K401 and K402 by turning the CONTROL SWITCH from MANUAL to AUTOMATIC and observing the relays for proper operation. If operation is faulty, refer to figures 30 and 260 and check the CONTROL SWITCH and manual-automatic relay circuit.
3. Safety interlock circuit.	3*a*. Check relay K502 to see that the contacts are closed and for improper spring tension.

PROBABLE LOCATION OF FAULT	PROCEDURE
	b. Refer to figures 30 and 260 and check continuity in the safety relay circuit.
4. Field power supply.	4*a.* Replace fuses F1153 and F1154. *b.* Check for approximately 300 volts output of the field power supply from pin C of J1153 to ground. *c.* Test tube V1152. Replace if defective. *d.* Make voltage and resistance checks at the socket of V1152 (figs. 205 and 341).

B. SYMPTOM: Faulty operation in azimuth with the CONTROL SWITCH in any position.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Azimuth channel of the azimuth and elevation tracking unit.	1*a.* Throw the meter switch to the AZIMUTH position. If the FIELD CURRENT meters do not indicate current, the fault is in the d-c amplifier circuit, commutator and squarer circuit, or the manual-automatic relays. If they do indicate current, the fault is in the drive motor or servo set. *b.* If the FIELD CURRENT meters are balanced at 25 ma, the fault is in the azimuth drive motor. *c.* If the FIELD CURRENT meters indicate current but are not balanced and cannot be balanced by adjustment of the BALANCE control, refer to symptom M.
2. Manual-automatic relays.	2. Check relays K401 and K402 as outlined in symptom A, fault 2.
3. D-c amplifier circuit.	3*a.* Check for an error signal at jacks J401 and J402. If no error signal, see 4 below. *b.* Test tubes V403 and V404. Replace if defective. *c.* Check R408 and R417 in the cathode circuit of the d-c amplifiers. *d.* Check the brushes and check for continuity of the field and armature of the servo generator. The fields of the servo generator are in the plate circuit of the d-c amplifiers. *e.* Make voltage and resistance checks at the sockets of V403 and V404 (figs. 213 and 340).
4. Commutators and squarer circuit.	4*a.* If the error signal is not present at jacks J401 and J402, test tubes V401, V402, and V408. Replace if defective. *b.* Make voltage and resistance checks at the sockets of V401, V402, and V408. (figs. 213 and 340).
5. Azimuth drive motor.	5*a.* Check brushes. *b.* Check continuity of the field and armature windings. *c.* Check the motor input and output voltage at the motor terminal strip.

C. SYMPTOM: Faulty operation in elevation with the CONTROL SWITCH in any position.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Elevation channel of the azimuth and elevation tracking unit or elevation drive motor.	1. Refer to symptom B above and make the indicated checks on the elevation components.

D. SYMPTOMS: 1. Faulty automatic operation. 2. Normal manual operation.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Signal circuits of automatic tracking unit.	1*a*. Place the set on the air and position the antenna manually so that an isolated, fixed target is in the narrow gate. *b*. Check with test scope for 30-cycle waveform at the COMMUTATOR INPUT jacks J504 and J505 to ground J503; if not present, the fault is in the signal circuits of the automatic tracking unit. *c*. If a flat topped 30-cycle wave is observed, the fault is improper bias on V504. Check for 2.9 volts at J510. If not present, the fault is in the balanced amplifier circuit. *d*. Check to see if the PLATE CURRENT meter indicates about 6 ma current. If it does, the fault is in the balanced amplifier circuit. If it does not, the fault may be in the first two stages of the automatic tracking unit.
2. Balanced amplifier circuit.	2*a*. Test tube V504. Replace if defective. *b*. Check at jacks J501 and J502 for 30-cycle output of coupling transformer T501. If not present, check to see that the antenna is spinning; check the secondary of T501 for continuity from pins 3 to 5, and see that pin 4 is grounded. *c*. Check that the coast relay is not closed. If it is cleared, the coast relay circuit is defective. Refer to fault 6 below. *d*. If 30-cycle signal is present at J501 and J502, make voltage and resistance checks at the socket of V504 (figs. 212 and 339).
3. No video input to automatic tracking unit.	3. Check with test scope for negative 50-volt video signal at pin 4 of V502. If not present check continuity of cable 64 from J702 of the receiver to J509.
4. Error signal detector and amplifier stages.	4*a*. Test tubes V502 and V503. Replace if faulty. *b*. Make voltage and resistance checks at the sockets of V502 and V503 (figs. 212 and 339).

PROBABLE LOCATION OF FAULT	PROCEDURE
5. Voltage regulator.	5*a*. Check to see if V505 has normal purple glow. If not, replace V505. *b*. Make voltage and resistance checks at the socket of V505 (figs. 212 and 339).
6. Defective coast relay circuit.	6*a*. Check for ground on terminals 5 and 2 of K501. *b*. Check for continuity of terminals 7 to 8 of relay K501. *c*. Check switch S1752.
7. Reference generator and spinner motor.	7*a*. Turn off the automatic tracking unit. Turn on the spinner motor. Observe if the dipole antenna is spinning. *b*. Remove the cable from J409 and check for the following voltages on the indicated pins of the cable plug (not the jack): I to G—100v ac (az ref v) J to G—100v ac (az ref v) K to G—100v ac (el ref v) O to G—100v ac (el ref v). If not present, fault is in the reference generator or transformers T1901 and T1902. *c*. Check continuity of reference generator windings and connections to the pedestal (fig. 260).
8. Defective manual-automatic relays.	8. Check relays K401 and K402 as outlined in symptom A, fault 2.

E. SYMPTOMS: 1. Faulty manual operation.
2. Normal automatic operation.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Antenna position indicator unit.	1*a*. Remove plug from J408. Check for the following voltages between the indicated pins of the plug: C to D; 0 to 115v ac E to F; 0 to 115v ac. *b*. These voltages should vary as the azimuth and elevation handwheels are turned. If not present, the fault is in the control selsyn, the selsyn transformer, or the local-remote relays. If these voltages are present, the fault is in the input transformers T401 or T451, or the manual automatic relays.
2. Reference voltage circuit.	2*a*. Check for 230 volts ac between pins G and H of the plug P408. If not present, the fault is in the 60-cycle reference voltage circuit. *b*. Check with the gun director repairman to see if excitation voltages are being fed from the director, or test by installing the selsyn excitation jumper. *c*. Check transformer T1202 by checking the continuity of the primary and secondary.

	d. Refer to figure 260 and make continuity checks of the circuit to locate the fault.
3. Faulty local-remote relays.	3*a.* Check relays K1201 and K1202 by operating the CONTROL SWITCH from the AUTOMATIC to the REMOTE position a few times and observing for proper operation of the relays.
	b. If operation is faulty, refer to figures 30 and 260 and check the CONTROL SWITCH and local-remote relay circuit.
4. No positioning voltage input to the azimuth and elevation tracking unit.	4*a.* Refer to figure 213 and check for continuity of the primary and secondary of T401 or T451.
	b. Refer to figure 213 and check the circuit wiring of the commutator and squarer tube grids for continuity and correct resistance values.
5. Mechanical gears and handwheel of the antenna position control unit.	5*a.* Turn the CONTROL SWITCH to the REMOTE position. If operation is normal, the fault is in the gears of the antenna position control unit or in the control selsyn.
	b. Check the operation of the gears by turning the handwheel slowly while observing for jerky or uneven movement and listening for an indication of broken gears or gear teeth.
6. Selsyn transformers.	6*a.* Check continuity of the rotor and stator windings.
	b. Turn the CONTROL SWITCH to the AUTOMATIC position and observe if the local azimuth index follows the movement of the antenna. If not, check that the azimuth selsyn orientation locking handle on the pedestal is tight. If this handle is loose, the selsyn transformer will have to be realigned with the antenna.
	c. Refer to figure 260 and check for continuity of the wiring and cabling of the selsyn transformer circuit.
7. Control selsyn.	7*a.* Inspect the brushes and slip rings.
	b. Check continuity of the rotor and stator windings.
	c. Replace the selsyn if necessary (subpar. 298**a**).

F. SYMPTOM: Faulty operation in PPI SCAN only.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Faulty scanning motor.	1*a.* Remove the antenna position control unit from the rack and check the scanning motor windings for continuity.
	b. If circuit is normal, install an extension cable and check the a-c voltage on pins K and N of J1301. This should be 115 volts ac.

PROBABLE LOCATION OF FAULT	PROCEDURE
	c. Check for approximately 40 volts ac across the armature of B1302.
2. Loose worm gear on the motor shaft.	2*a*. Disconnect the extension cable and remove the housing over the worm gear.
	b. Test the motor shaft and gears with the finger. Tighten the gear if necessary.

G. SYMPTOM: Faulty operation in REMOTE only.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Faulty local-remote relays.	1. Check the operation of the local-remote relays K1201 and K1202 as outlined in symptom E, fault 3.
2. Defective wiring from the director.	2*a*. Make continuity check of the cable to the director.
	b. Check with the repairman of the gun director.

H. SYMPTOM: Erratic or jerky operation in azimuth with the CONTROL SWITCH in any position.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Defective tube V405.	1. Test V405. Replace if defective.
2. Anti-hunt limiting circuit.	2*a*. Remove V406. Turn the CONTROL SWITCH to the MANUAL position. Check to see if operation is normal in this position. If it is normal, the trouble is in the anti-hunt limiting circuit.
	b. Test V406. Replace if defective.
	c. Check for 8 to 9 volts between J411 and J413 (with J411 positive) and between J412 and 413 (with J413 positive). If these values are not obtained, adjust the AH LIMITING CONTROL to try to obtain them.
	d. If there is no voltage difference between J411 and J413, refer to figure 213 and check resistors R413, R414, R415, and R416.
	e. If there is an excessive voltage difference in J411 and J413, check C403 and the wiring in the jack circuits.
	f. If the voltage difference between J411 and J413 cannot be varied by the AH LIMITING CONTROL, check to see that the AH LIMITING CONTROL is wired correctly (so that its contacts move in opposite directions).
	g. Take voltage and resistance measurements at the socket of V406 (figs. 213 and 340).
3. Anti-hunt amplifier circuit.	3*a*. Turn CONTROL SWITCH to the MANUAL position, throw the AZIMUTH MOTOR switch to the ON position, turn the azimuth AH GAIN control to zero.

	b. Give the azimuth handwheel a sudden turn. The reflector should start hunting. If it does not, make voltage and resistance checks at the socket of V405 (figs. 213 and 340).
	c. Advance the AH GAIN control until the hunting stops. If it does not stop, refer to figure 260 and check continuity through J409 to all servo generator terminals.
	d. Short around capacitors C404 and C405 and repeat steps *a*, *b*, and *c* above. If hunting does not stop at the same setting of the AH GAIN control as in *c* above; remove the short, check L403, C404, C405, R422, R423, R424, and R434 for continuity, shorts, and correct ohmic values.
4. Torque-limiting circuit.	4*a.* Test tube V407 and replace if defective.
	b. Check for 3 to 4 volts between J413 and J414 with J414 positive. Try to adjust to 3 or 4 volts by varying the TORQUE CONTROL R433.
	c. If there is no voltage difference between J413 and J414, check R433.
	d. If the voltage difference between J413 and J414 is excessive, check for open or short to ground in J414 circuit wiring.
	e. Turn the CONTROL SWITCH to the MANUAL position, throw the AZIMUTH MOTOR switch to the ON position. Give the azimuth handwheel a quick turn and note the behavior of the reflector and the sound of the servo generator.
	f. Remove V407 and repeat step *c* above. If the motion of the reflector is not jerkier and the whine of the servo generator is not greater; refer to figure 260 and make resistance and continuity checks in the drive motor circuits.
	g. Make voltage and resistance checks at the socket of V407 (figs. 213 and 340).
5. Faulty safety relay K502.	5. Check the safety relay interlock circuit as outlined in symptom A, fault 3.

I. SYMPTOM: Erratic or jerky operation in elevation with the CONTROL SWITCH in any position.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Torque-limiting or anti-hunt circuits.	1. Refer to symptom H above and check the corresponding parts in the elevation channel.

J. SYMPTOM:	Antenna slews considerable in azimuth when the CONTROL SWITCH is turned from the AUTOMATIC to the MANUAL position.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Azimuth and elevation tracking unit.	1. Throw the AZIMUTH MOTOR switch to the OFF position. Turn the CONTROL SWITCH to the AUTOMATIC position. Throw the SPINNER MOTOR switch to the ON position. Turn the GAIN control on the automatic tracking unit to zero. The FIELD CURRENT meters should read approximately 25 ma each with the meter switch in the AZIMUTH position. If they do not, refer to symptoms B and H above.
2. Follow-up motors or control circuits defective.	2*a*. Check the operation of relays K401 and K402 as outlined in symptom A, fault 2.
	b. Remove the antenna position control unit from the control rack. Spin the gear of the follow-up motor B1303. It should turn smoothly and very easily and coast to a stop rather slowly.
	c. Hold the magnetic brake clear of the gear. If the motor does not turn easily, check for something which may be jamming the gears.
	d. Connect the test cable between J1301 and P1301 and check that the voltage across terminals 2 and 4 of motor B1303 is approximately 20 volts. If not, check to see if the voltage across terminals 1 and 2 (primary) of transformer T1302 is 115 volts ac.
	e. Check that the voltage across terminals 1 and 3 of motor B1303 varies from approximately ¼ volt to 5 or 6 volts as the azimuth handwheel is rotated. (The control switch on the control panel must be on AUTOMATIC and the magnetic brakes should energize.) If voltage is correct, replace the motor.
	f. If voltage does not appear on the motor terminals, see if approximately 1 to 6 volts appear on terminals 1 and 2 of transformer T1301 as the handwheel is rotated. If so, the transformer is bad.
	g. If no voltage appears on the transformer, remove power and check continuity back through the circuit to the selsyn transformers in the pedestal and refer to figure 260 to trace this circuit.

K. SYMPTOM: Antenna slews considerably or to a limit in elevation when the CONTROL SWITCH is turned from the AUTOMATIC to the MANUAL position.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. FIELD CURRENT meters circuit, follow-up motors, control circuits.	1. Refer to symptom J and check the corresponding parts in the elevation channel.

L. SYMPTOMS: 1. In automatic operation, the reflector is sluggish or positions itself with an excess of overshoots (more than 3).
2. Adjustment of GAIN control does not reduce sluggishness or overshoots.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Voltage regulation circuit.	1. Refer to symptom D, fault 5.
2. GAIN control circuit.	2. Check potentiometers R505 and R506 for proper operation.
3. AVC control.	3. Check the reading of the PLATE CURRENT meter, if more than 6 ma refer to symptom D, fault 4.

M. SYMPTOMS: 1. FIELD CURRENT meters are not balanced.
2. Meters cannot be balanced by adjustment of the BALANCE CONTROL.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Defective tubes.	1. Test tubes V403, V404, V405, and V406. Replace any that are defective.
2. D-c amplifier plate and screen circuits.	2*a*. Short J404 to J405. If meters can now be balanced, refer to fault 3 below.
	b. Make voltage and resistance checks at the sockets of V403, V404, and V405 (figs. 213 and 340).
	c. Refer to figure 213 and check continuity of the meter switch S401.
3. D-c amplifier grid circuits.	3*a*. Remove tube V407. It should have no effect on the meter readings. If it does, make voltage checks at the socket of V407 or replace V407.
	b. Replace V401, V402, and V408 (one at a time).
	c. Short J401 to J404 and observe the meter readings. Remove the short. Short J402 to J405 and observe the meter readings. If either operation changes the meter readings; check C401 and C402 for leakage, check L401 and L402 for continuity, and check R407, R409, and R421 for improper resistance values.
	d. Check the d-c voltage from J401 to J402, from J401 to ground, and from J402 to ground. Voltage between J401 and J402 should be less than ½ volt. Voltage from

	J401 and J402 to ground should be approximately 75 volts. If these values are not obtained, make voltage and resistance checks at the sockets to V401, V402, and V408; and refer to figures 213 and 340 to locate the fault.
4. BALANCE control circuit.	4. Check resistors R515, R516, and R517.

297. ALIGNMENT PROCEDURES.

The following alignment and adjustment procedures cover the complete automatic tracking and servo systems. The first procedure is the alignment of the servo system, and is performed on the manual control circuits. The second procedure is the alignment of the automatic tracking circuits and is performed using a fixed ground target. If any of the meter or control settings in each step cannot be obtained refer to the symptom given after the step for the procedure to locate the fault.

a. Alignment of Servo System.

(*1*) Turn the CONTROL SWITCH on the indicator-control panel to the MANUAL position. Throw the SAFETY switch on the indicator-control panel to the STOP position. Throw the power switch on the automatic tracking unit to the ON position. The red pilot light on the automatic tracking unit should light. After 30 seconds warm-up, the PLATE CURRENT meter on the automatic tracking unit should read approximately full scale. Refer to symptom A, fault 1.

(*2*) Check the d-c voltage from J413 (+ 30v) to J411 on the azimuth and elevation tracking unit. It should be 8 to 9 volts, J411 being positive. Adjust the voltage, if necessary, by means of the AH LIMITING CONTROL on the azimuth and elevation tracking unit. Lock the control. Refer to symptom H, fault 2.

(*3*) Check the d-c voltage from J413 (+ 30v) to J414. It should be 3 to 4 volts, J414 being positive. Adjust the voltage, if necessary, by means of the TORQUE CONTROL on the azimuth and elevation tracking unit. Lock the control. Refer to symptom H, fault 4.

(*4*) Check the d-c voltage from J510 in the automatic tracking unit to ground. It should be 2.9 volts. Adjust the voltage, if necessary, by means of the VOLTAGE CONTROL on the automatic tracking unit. Lock the control.

(*5*) Check that the voltage from J413 (+ 30v) to ground is between 26 and 30 volts. Refer to symptom H, fault 2.

(*6*) Adjust the azimuth handwheel on the antenna position control unit so that the FIELD CURRENT meters are balanced. If the balance current is not 25 ma ± 2ma, adjust the current readings to 25 ma by means of the azimuth CURRENT CONTROL R408 on the chassis of the azimuth and elevation tracking unit. Lock the control. Refer to symptom M.

(*7*) Turn the CONTROL SWITCH to the AUTOMATIC position. Throw the SAFETY switch on the indicator-control panel to the RUN position. Turn the CONTROL SWITCH back to the MANUAL position. Throw the meter key switch on the azimuth and elevation tracking unit to the AZIMUTH position. The FIELD CURRENT meters should be nearly balanced. If they are not, the azimuth follow-up motor is not functioning properly. Refer to symptom J, fault 2.

(*8*) Throw the meter switch to the ELEVATION position. Adjust the elevation handwheel to balance the meter readings. If the balance current is not 25 ma ± 2 ma, adjust the current readings to 25 ma by means of the elevation CURRENT CONTROL R458. Lock the control. Refer to symptom M.

(*9*) Throw the AZIMUTH MOTOR and the ELEVATION MOTOR switches on the switch and data panel to the ON position. Throw the SAFETY switch to the RUN position. The reflector may move slightly, but it should stabilize quickly. Elevation may run up or down to the stop. Refer to symptom H.

(*10*) Rotate the elevation handwheel until control of the reflector is obtained, and elevate the reflector to about 800 mils. Clockwise rotation of the elevation handwheel on the antenna position control unit should cause the following:

(*a*) The reflector should elevate.

(*b*) The local elevation index on the antenna position indicator unit should move in a clockwise direction.

(*c*) The right-hand meter on the azimuth and elevation tracking unit should read low while the reflector is moving and the meter switch is in the ELEVATION position. Refer to symptom E.

(*11*) Clockwise rotation of the azimuth handwheel on the antenna position control unit should cause the following:

(*a*) The reflector should rotate clockwise.

(*b*) The local azimuth index on the antenna position indicator unit should rotate clockwise.

(*c*) The right-hand meter on the azimuth and elevation tracking unit should read high while the reflector is moving and the meter switch is in the AZIMUTH position. Refer to symptom E.

(*12*) Turn the CONTROL SWITCH to the AUTOMATIC position. Turn the azimuth and elevation AH GAIN controls maximum counterclockwise (minimum gain). Adjust the azimuth and elevation BALANCE controls on the azimuth and elevation tracking unit until the drifting motion of the reflector stops. Return the AG GAIN controls to their former positions. Refer to symptom M, fault 4.

(*13*) Turn the CONTROL SWITCH to the MANUAL position. Turn the elevation AH GAIN control maximum counterclockwise (minimum gain). Move the elevation handwheel slightly. The reflector will oscillate in elevation. Turn the elevation AH GAIN control very slowly clockwise until the oscillations just cease.

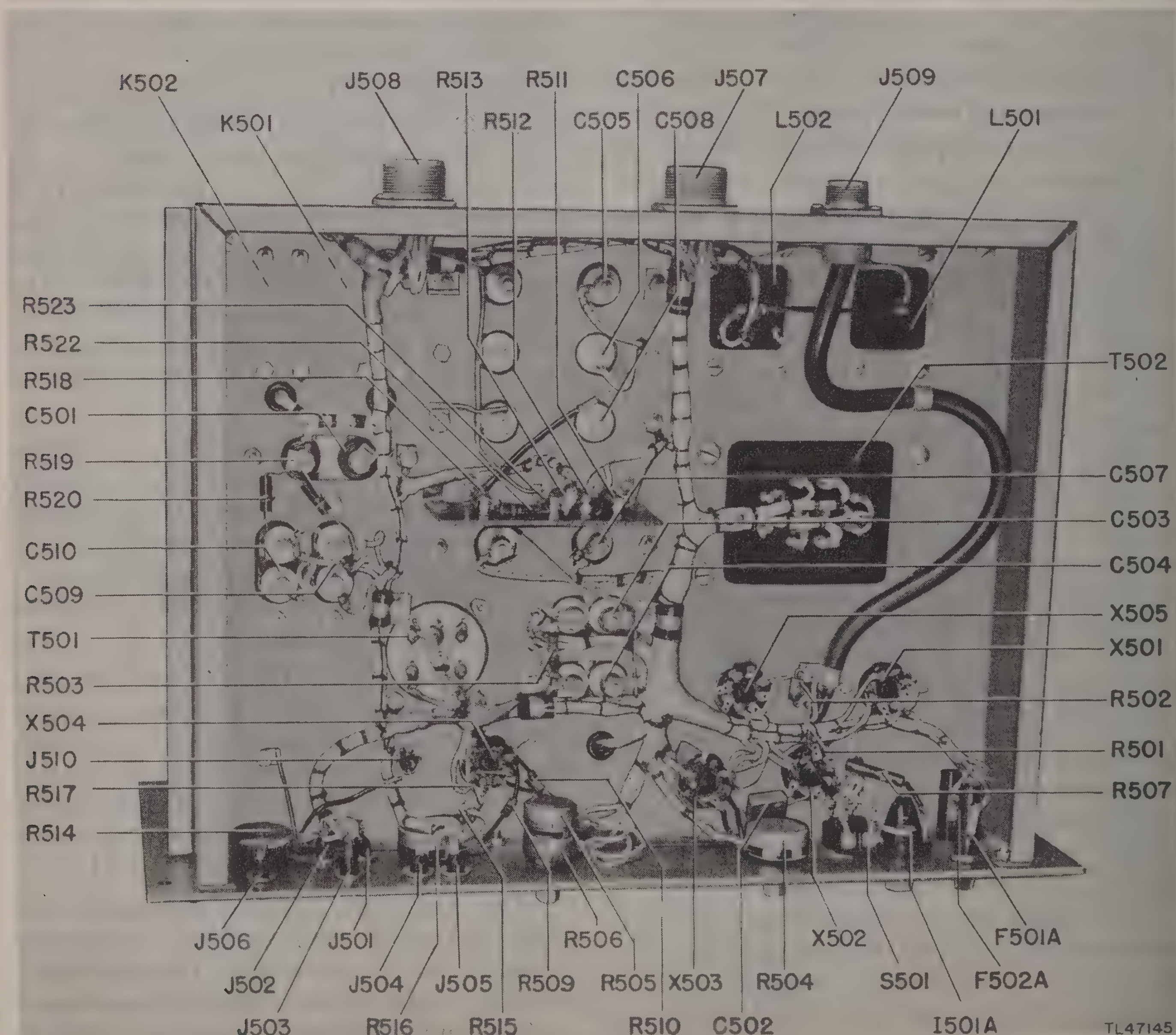


Figure 329. Automatic tracking unit, bottom view, parts identified.

This adjustment should be done several times to get the best control position. Refer to symptom H, fault 3.

(*14*) Set the reflector at about 800 mils elevation. Turn the CONTROL SWITCH to the PPI SCAN position. The reflector should rotate clockwise at 5 rpm (plus or minus ¼ rpm) in azimuth. During 5½ rotations in azimuth it should elevate slowly 356 mils. The reflector should then drop to the original elevation position during ½ revolution in azimuth and should again start to elevate slowly. The local indexes on the antenna position indicator unit should follow the motion of the reflector. Refer to symptom F.

(*15*) Reduce the azimuth AH GAIN control setting to about half its normal setting. The azimuth scanning will not be smooth. Increase the azimuth AH GAIN control setting slowly until the sound of the azimuth scan becomes smooth. Refer to symptom H, fault 3.

(*16*) Position the reflector at about 800 mils elevation. Turn the CONTROL SWITCH to the AUTOMATIC position. If the azimuth and elevation amplifiers have been properly balanced, the reflector will not drift appreciably. Turn the azimuth and elevation handwheels 5 revolutions clockwise. Wait 5 seconds, then turn the CONTROL SWITCH to the MANUAL position. The reflector should not move more than 100 mils in either azimuth or elevation. If it does, the follow-up motors are not functioning properly. Refer to symptom J for corrective measures.

(*17*) Repeat step (16) above with counterclockwise rotation of the handwheels.

b. Alignment of Automatic Tracking Circuits.

(*1*) Make the following preliminary adjustments:

(*a*) Throw the SPINNER MOTOR switch on the switch and data panel to the ON position.

(*b*) Place the transmitter and receiver in normal operation according to the starting procedure.

(*c*) Position the reflector so that it is pointed at a strong fixed target. The target used for this alignment should be isolated (no other targets closer than 1,000 yards in range), and it should be a target that, with the receiver AGC switch in the AGC position, the target in the narrow gate, and the reflector positioned accurately on the target, the signal seen on the range scopes is a clean, clear, echo signal with modulation of not more than one third of the signal amplitude.

(*d*) Decrease the width of the narrow gate to about 200 yards, and position the narrow gate so that the target is centered on it.

(*e*) Throw the receiver AGC switch to the AGC position.

(*f*) Check to see that the GAIN control on the automatic tracking unit is set to its normal position.

(*g*) Set up the test scope and set its sweep speed to show about 6 cycles of a 60-cycle wave. Connect the test scope to the COMMUTATOR INPUT J504 on the automatic tracking unit and to ground. Set the scope vertical gain so that the maximum amplitude of the error signal that can be obtained, by moving the reflector approximately 50 mils off the target, is about 4 inches.

(*2*) Position the reflector carefully by means of the handwheels, so that the amplitude of the 30-cycle error signal viewed on the test scope is reduced to zero.

(*3*) Adjust the AVC control on the automatic tracking unit so that the meter on the automatic tracking unit reads 6 ma. Refer to symptom A.

(*4*) Adjust the balanced amplifier and elevation reference voltage by the following procedure:

(*a*) Rotate the azimuth handwheel clockwise to move the reflector 50 mils. A large 30-cycle sine-wave error signal appears on the test scope.

(*b*) Check with the test scope to see that equal amplitudes of error signal are obtained from the COMMUTATOR INPUT jacks J504 and J505. If necessary, adjust the BALANCE control on the front panel of the automatic tracking unit to balance the error signals.

(*c*) Turn off both servo generators. Wait until the servo generators have stopped rotating, then turn the CONTROL SWITCH to the AUTOMATIC position.

(*d*) Measure the reference voltage between the following terminals at the switch and data panel: TB18-7 to TB18-6, to TB18-8, to TB18-9, and to TB18-10. In each of these measurements the reference voltage should be 115 volts a-c (± 10 volts), and the meter pointer should be steady. If the meter pointer is not steady, it is probably because of improper or shorted connections in the azimuth and elevation

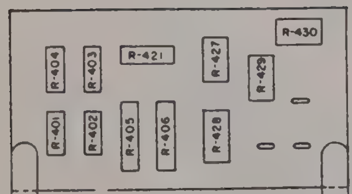


FIGURE A

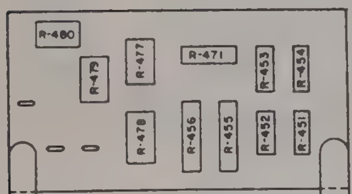


FIGURE B

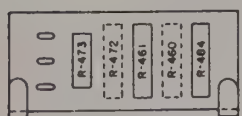


FIGURE C

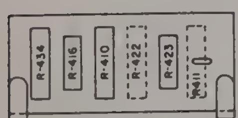
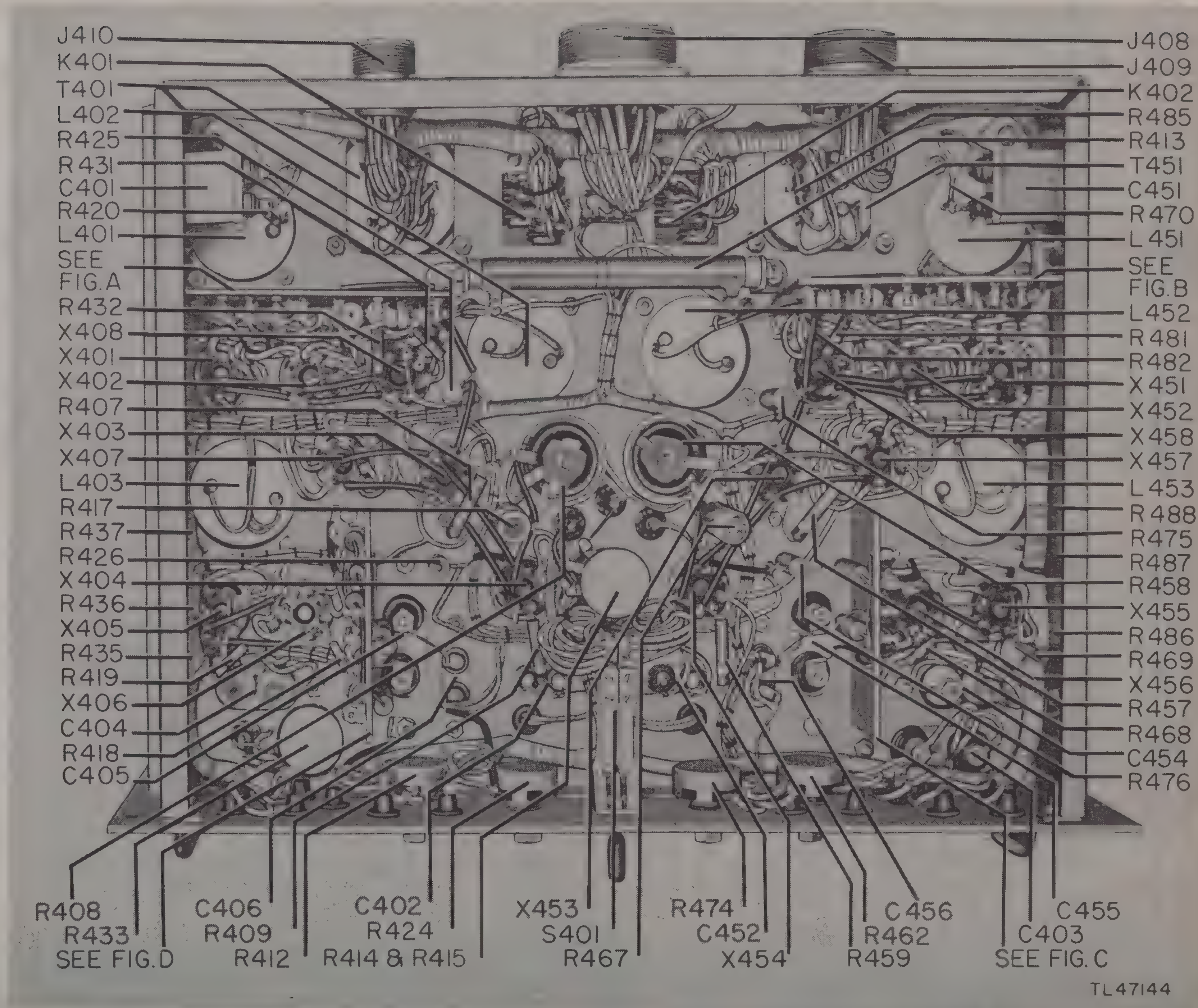


FIGURE D



tracking unit causing a 60-cycle voltage from the a-c supply to be impressed on the 30-cycle reference voltage. If any voltages are approximately 140 volts, check the wiring connections from the reference generator.

(*e*) Throw the meter switch to the ELEVATION position. Note the amount of unbalance of the FIELD CURRENT meters. Throw the meter switch to the AZIMUTH position. The unbalance of the meters with the switch in the AZIMUTH position should be the greater. If it is not, the reference generator is not connected properly. The right-hand meter should read low, and the left-hand meter should read high. If the unbalance is in the reverse direction, the connections to the reference-generator transformer T1901 of the switch and data panel are probably reversed.

(*f*) Throw the meter switch to the ELEVATION position. Unlock the field adjustment of the reference generator by loosening the locknut on the threaded shaft extending from the rear of the housing. Turn the threaded shaft to obtain a balance on the FIELD CURRENT meters. Tighten the locknut on the shaft.

(*5*) Check the azimuth reference voltage according to the following procedure:

(*a*) Turn the CONTROL SWITCH to the MANUAL position and turn on the servo generators. Position the reflector exactly on target by reducing the 30-cycle error signal viewed on the test scope to zero. Elevate the reflector 50 mils.

(*b*) Turn off the servo generators. Wait until the servo generators have stopped rotating and then turn the CONTROL SWITCH to the AUTOMATIC position.

(*c*) Throw the meter switch to the ELEVATION position. The right-hand FIELD CURRENT meter should read high, and the left-hand meter should read low. If the unbalance is in the opposite direction, the connections to the reference-generator transformer T1902 on the switch and data panel are probably reversed.

(*d*) Throw the meter switch to the AZIMUTH position. The FIELD CURRENT meters should be balanced. If the meters are not quite balanced, unlock the field adjustment of the reference generator, and turn the threaded shaft until the meters are balanced. Tighten the locknut on the shaft. If the meters are greatly unbalanced, the common lead of the field windings of the reference generator is probably connected to the wrong terminal. Check this by measuring the resistance between the lead being used as the common lead, and each of the other leads. The resistances should be equal. If not, change the leads and repeat steps (4) and (5) above. Refer to symptom D.

(*6*) Turn the CONTROL SWITCH to the MANUAL position. Turn on the servo generators. Disconnect the test scope. Move the reflector 50 mils off the target first in azimuth and then in elevation. Check to see that, in both cases, when the CONTROL SWITCH is turned to the AUTOMATIC position, the reflector quickly positions itself on the target with not more than three overshoots. If more than three overshoots are obtained, turn the GAIN control on the automatic tracking unit in the counterclockwise direction, until not more than three overshoots are obtained. Refer to symptom L. When checking azimuth, the elevation should not vary more than approximately 12½ mils and when checking elevation the azimuth should not vary more than approximately 12½ mils. If the variation is more than 12½ mils in either case, check the adjustment of the reference generator as described in steps (4) and (5) above. If the movement of the reflector seems sluggish, turn the GAIN control in a clockwise direction. Refer to symptom L.

298. REPLACEMENT OF PARTS.

a. Replacement of Control Selsyn B1301 or B1351.

(*1*) Remove the antenna position control unit from the rack.

(*2*) Refer to figures 207 and 331, top and bottom views of the antenna position control unit to show location of the control selsyns.

(*3*) Remove the tubular rail which extends from the rear of the front panel plate to the rear of the chassis.

(*4*) Remove the three screws and clamps which hold the control selsyn to its mounting.

(*5*) Remove the lead wires from the selsyn and tag them for reference.

(*6*) Remove the selsyn by pulling it out slowly and straight back from its mounting, twisting it slowly back and forth as it is pulled out. This selsyn, being ball-bearing mounted, has a drive gear on both the stator and the rotor. If the selsyn is cocked and pulled out roughly, the gears will be damaged.

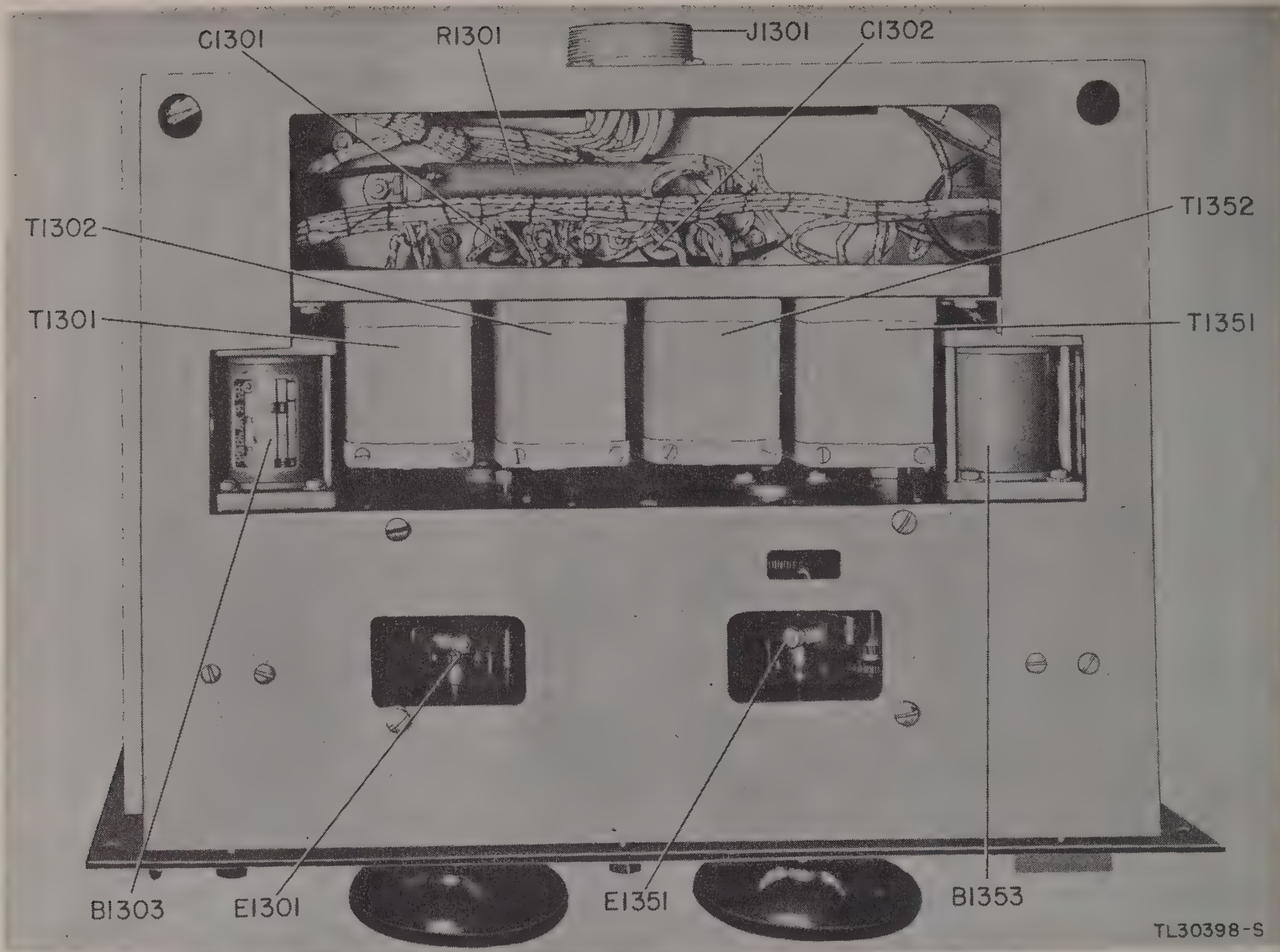


Figure 331. Antenna position control unit, bottom view, parts identified.

(*7*) After removing the selsyn, remove the screw and washer which clamp the rotor drive gear onto the rotor shaft.

(*8*) There is a split key in the gear hub. This key may or may not be removed to pull off the gear. After the rotor drive gear has been removed, remove the stator drive gear by removing the four screws which hold the gear onto the stator.

(*9*) Before installing a new selsyn, check to see that the stator and rotor revolve without binding.

(*10*) Before installing the gears on the new selsyn, try the selsyn in its mounting to be sure it will fit.

(*11*) Install the gears on the new selsyn, putting the stator gear on first.

(*12*) Before installing the new selsyn, check to see that its mounting hole is free of all dirt and burrs. Wipe out with a lint-free rag.

(*13*) Install the new selsyn into its mounting. To do this, line it up by sliding the mounting flange into its seat evenly, and then slowly working it forward. DO NOT FORCE THE SELSYN INTO ITS MOUNTING.

(*14*) Replace the three screws and clamps which hold the selsyn onto its mounting.

(*15*) Replace the tubular rail.

(*16*) Replace the antenna position control unit in the rack.

b. Replacement of PPI Scan Motor B1302.

(*1*) Remove the antenna position control unit from the rack.

(*2*) Refer to figure 207 for location of the scanning motor.

(*3*) Loosen the elevation control selsyn in its mounting.

(*4*) Remove the two hex. screws which hold the motor on its mounting bracket. Be careful not to lose the shims under the motor base.

(*5*) The motor, with the jaw clutch mounted on its shaft, may now be pulled from the unit.

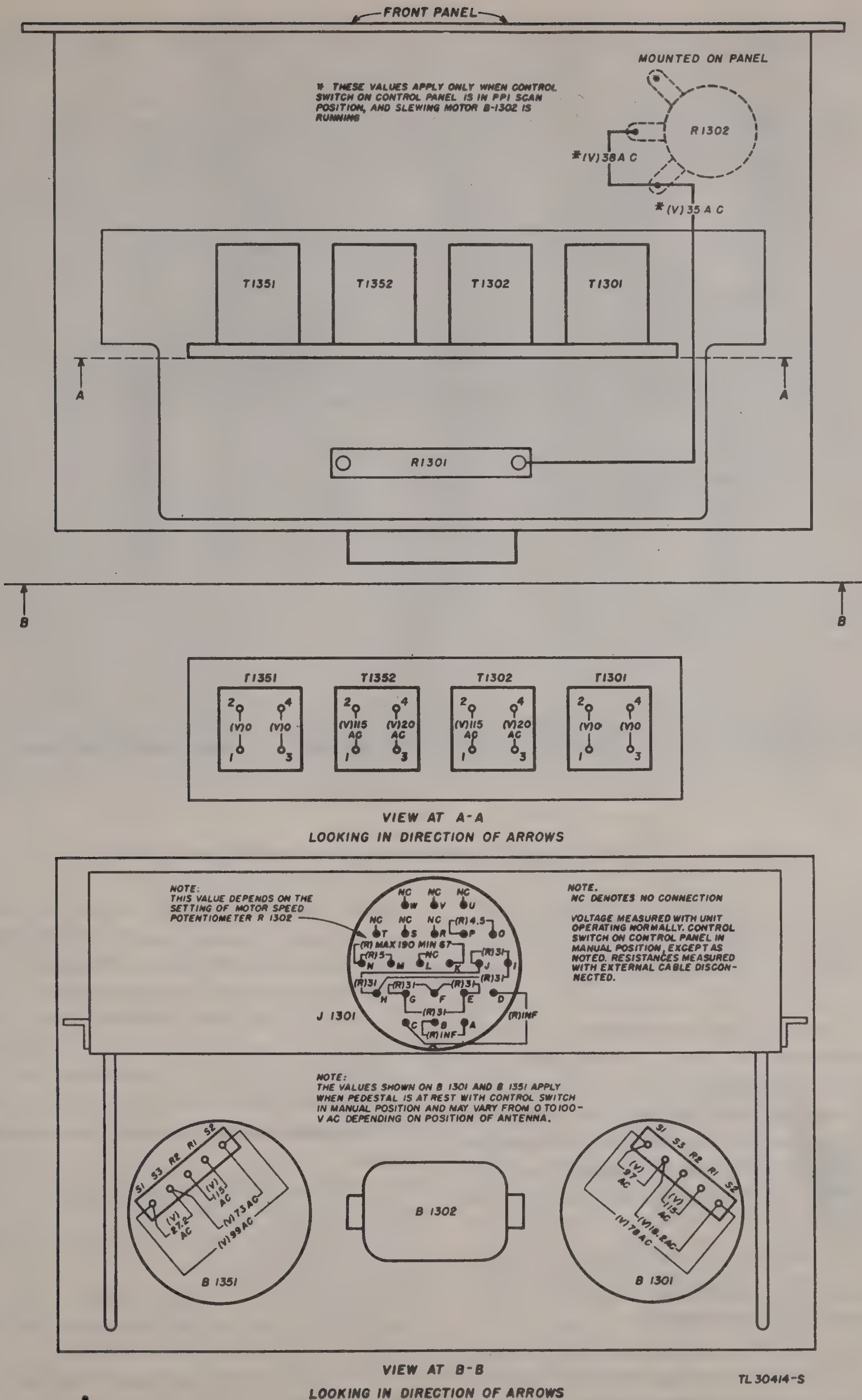


Figure 332. Antenna position control unit, voltage and resistance chart.

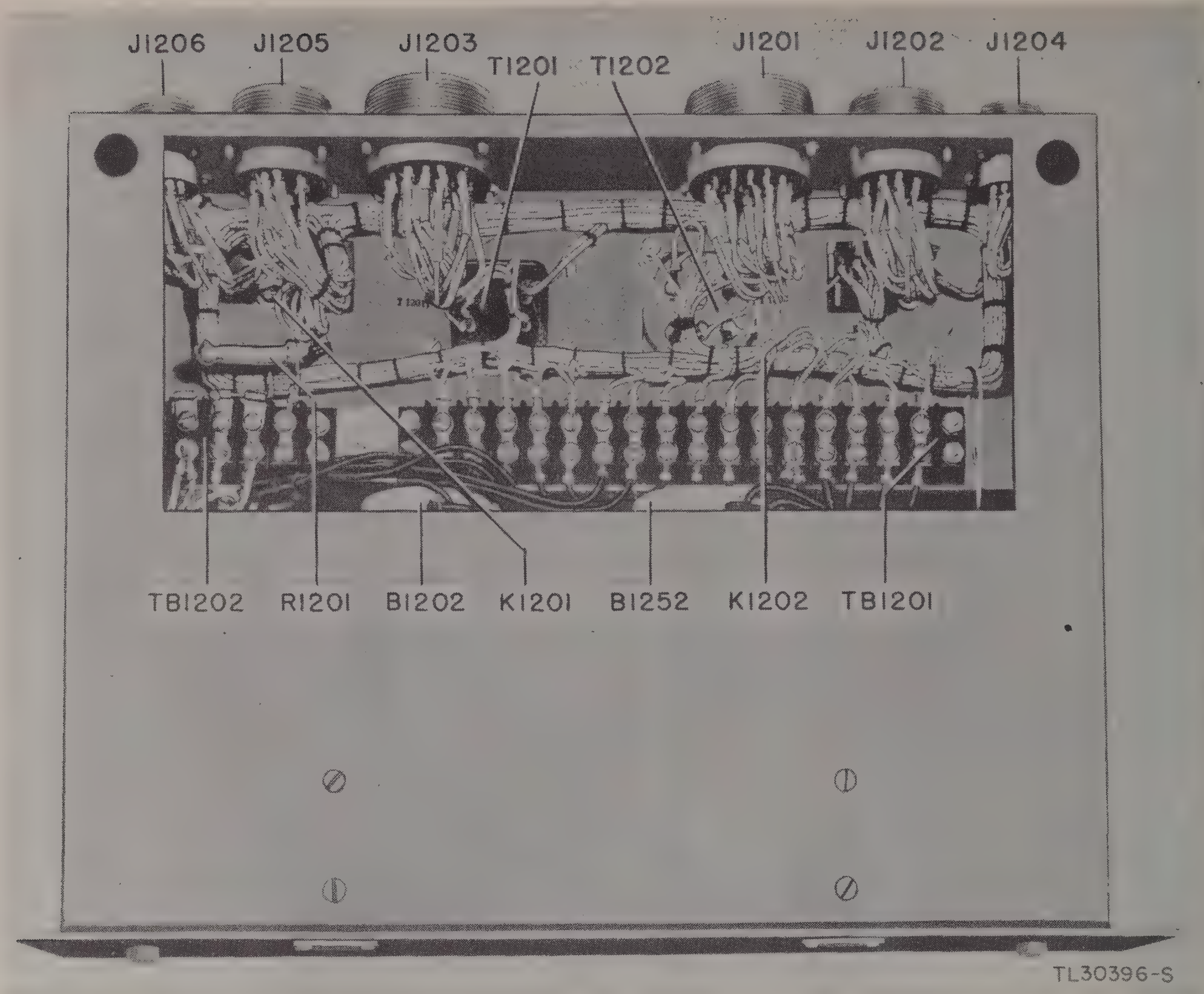


Figure 333. Antenna position indicator unit, bottom view, parts identified.

(*6*) Remove the motor lead wires from the terminal board and tag for use in replacement.

(*7*) Remove the jaw clutch from the motor shaft.

(*8*) Assemble the jaw clutch on the shaft of the new motor.

(*9*) Replace the new motor on its mounting bracket, making sure to insert the shims underneath the motor base. Be sure that the jaw clutch on the motor shaft engages the drive tongue of the worm which is mounted inside the casting.

(*10*) Connect the wires to the new motor.

(*11*) Before proceeding any further with the reassembly, run the motor.

(*12*) It may be found, when the motor is run, that there is a rattling noise at the point where the jaw clutch engages the drive tongue. This is due to the bodies of these two parts hitting each other at some point of their rotation. This rattling noise can be overcome by loosening the mounting screws slightly and shifting the motor from side to side, or by adding or subtracting shims under the motor base.

(*13*) Tighten the elevation control selsyn in place.

(*14*) Replace the antenna position control unit in the rack.

c. Replacement of Follow-up Motor B1303 or B1353.

(*1*) Remove the antenna position control unit from the rack.

(*2*) Refer to figure 331 for location of the follow-up motors.

(*3*) Remove the lead wires to the motor and tag these wires for convenience in replacement.

(*4*) Pull the chassis away from the unit as far as possible in order to gain access to the four motor holding screws. This requires the services of at least two men. Before removing

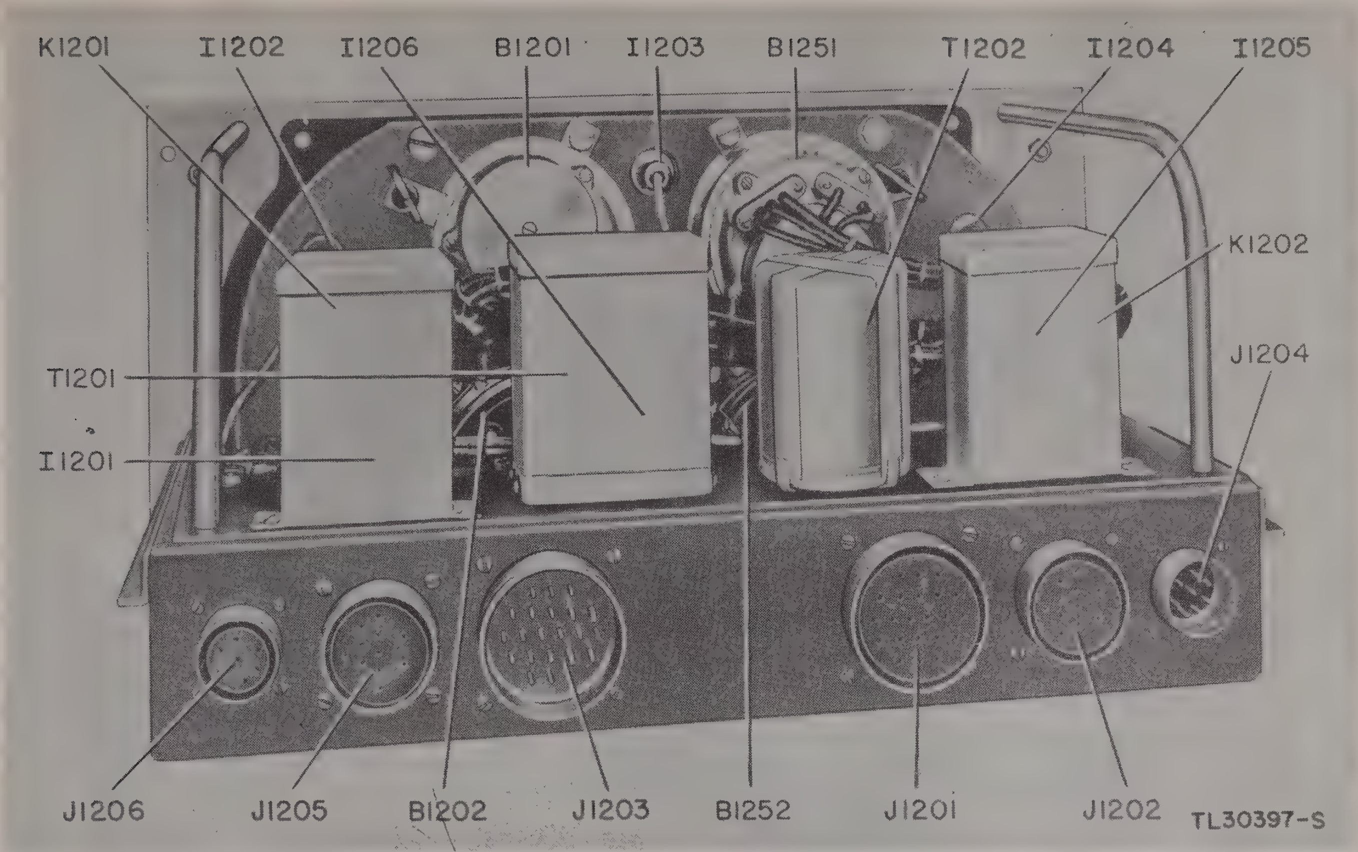


Figure 334. Antenna position indicator unit, rear view.

chassis, notice that there is a small electrical brake mounted on the chassis. This brake contacts the gear which is driven by the motor pinion. Be careful not to injure this brake when removing or replacing the chassis.

(*5*) After the chassis has been pulled away from the unit, remove the four screws which hold the motor to the rear bearing plate. Remove the motor.

(*6*) Remove the gear from the motor shaft and mount it on the shaft of the new motor.

(*7*) Mount the new motor on the rear bearing plate in the same manner as the old motor was mounted. It is important that considerable backlash should exist between the gear on the motor shaft and the gear with which it meshes.

(*8*) Spin the gear train with the finger. It should coast to a stop slowly. It is important that the gear train from the motor up to the selsyn stator runs very freely.

(*9*) Tighten the four motor holding screws.

(*10*) Replace the chassis, being careful not to injure the electrical brake.

(*11*) Replace the motor leads.

(*12*) Replace the antenna position control unit in the rack.

d. Replacement of Local Receiving Selsyn B1201 or B1251.

(*1*) Remove the antenna position indicator unit from the rack.

(*2*) Remove the thumbscrew and clamp underneath the selsyn.

(*3*) Note that when the thumbscrew is removed, the selsyn rotates freely but still will not have excessive looseness in its mounting hole. This is because the two remaining clamps on the selsyn have been so assembled as to provide a minimum amount of clearance between the selsyn shoulder and the shoulder of the clamp and yet allow the selsyn to revolve with complete freedom. These two clamps have shims underneath them. Care should be taken so that they are not lost.

(*4*) Remove the two remaining clamps and their shims. The entire selsyn with the gear attached to its shaft may now be removed. Be careful in removing the selsyn so as not to injure the gear on the selsyn shaft.

(*5*) Unscrew the selsyn leads from the terminal board. Tag the leads for ease in replacement.

(*6*) The gear on the selsyn shaft is now ready to be removed. At this point, notice which way the hub of the gear is pointing (to-

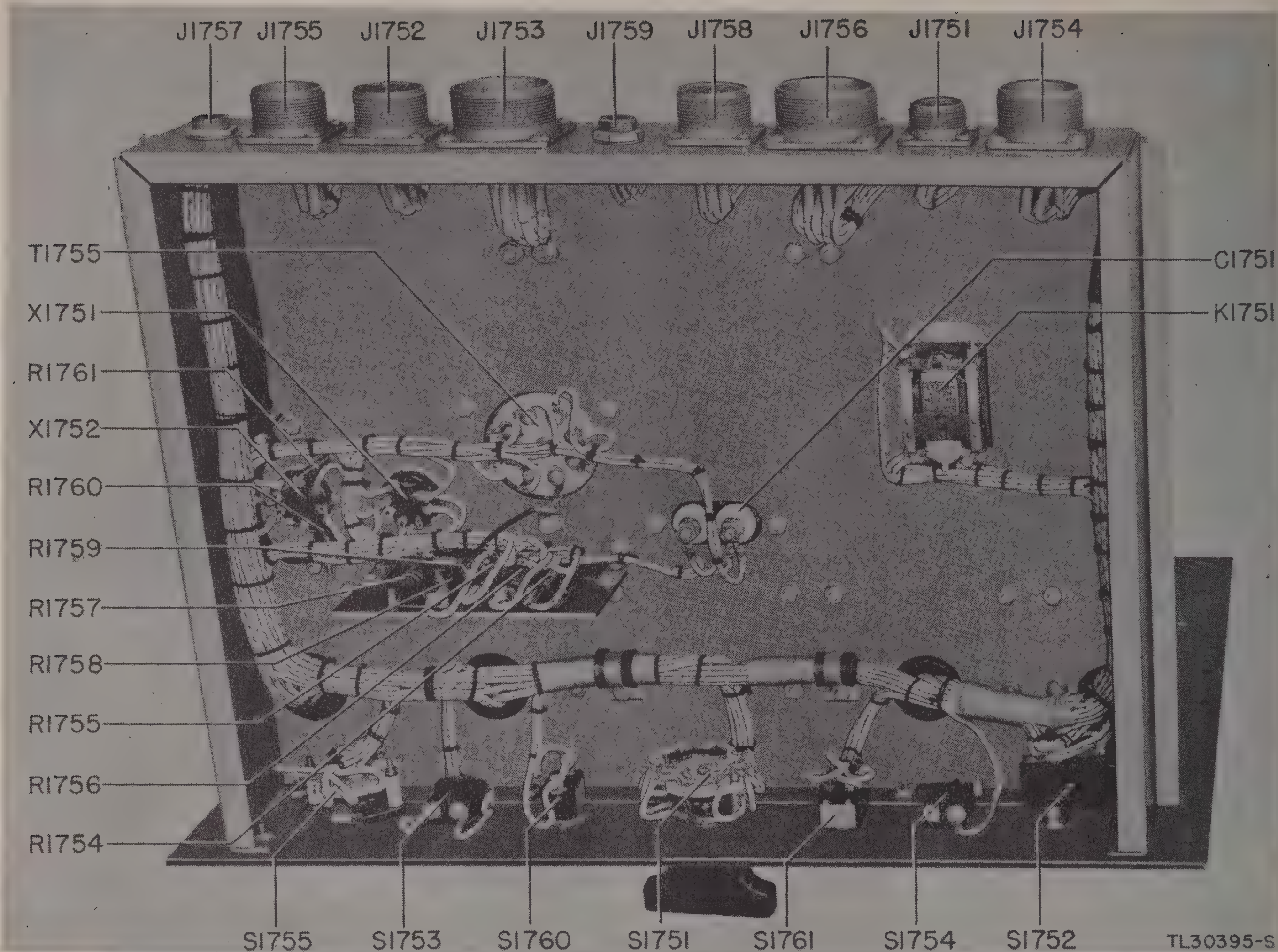


Figure 335. Indicator-control panel, bottom view, parts identified.

ward or away from the selsyn body). Take the gear and key off the selsyn shaft by removing the nut which is screwed on the selsyn shaft.

(*7*) Insert the key into the new selsyn and assemble the gears on the shaft in the same manner as it was assembled on the original selsyn.

(*8*) The selsyn, with the gear mounted in place, is now ready to be reassembled back into the unit. This should be done with extreme care so that the gear teeth are not injured.

(*9*) Replace the selsyn clamps and thumbscrew.

(*10*) Connect in the new selsyn.

(*11*) Synchronize the selsyn as given under the orientation and synchronization procedure of TM 11-1324.

e. Replacement of Remote Receiving Selsyn B1202 or B1252.

(*1*) Remove the antenna position indicator unit from the rack.

(*2*) Remove the six screws which hold the front panel to the tubular bars and the chassis.

(*3*) Remove the four screws that fasten the gear housing to the bottom of the chassis.

(*4*) Pull the front panel and gear housing out from the chassis as far as the wires permit.

(*5*) Remove the selsyn as outlined in subparagraph **d** above, steps (*2*) to (*10*).

(*6*) Replace the front panel and gear housing and their holding screws.

(*7*) Replace the antenna position indicator unit in the rack.

f. Replacement of Dial Lights of the Antenna Position Indicator Unit.

(*1*) Slide the unit from the rack just far enough to reach the dial light sockets.

(*2*) Remove the socket from its mounting hole and replace the bulb.

(*3*) Replace the socket and return the panel to its operating position.

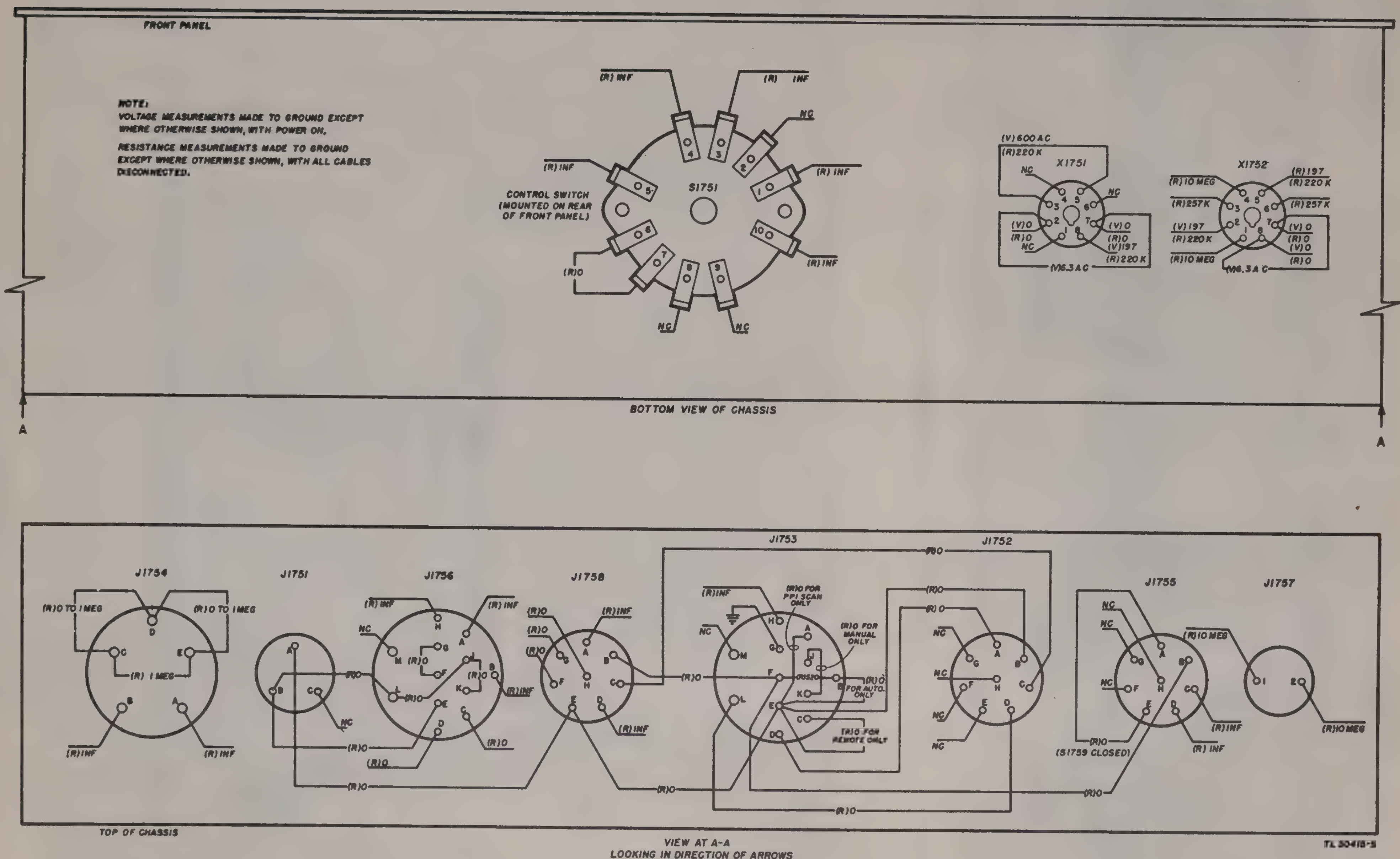


Figure 336. Indicator-control panel, voltage and resistance chart.

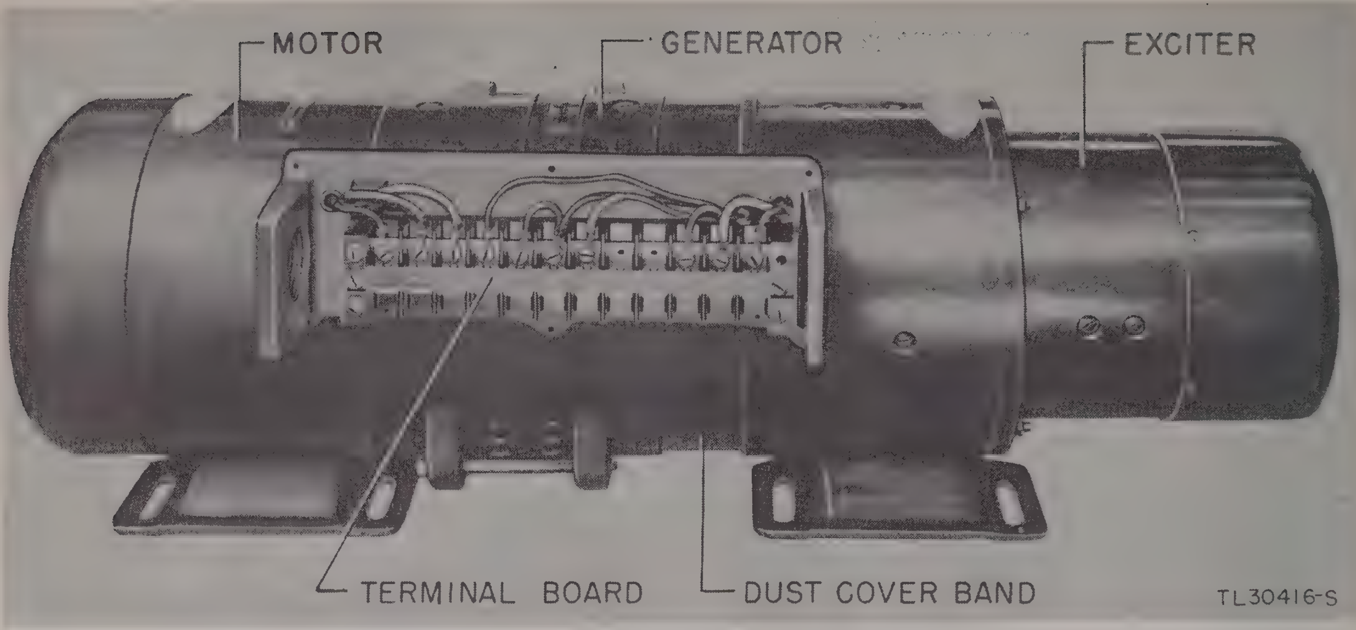


Figure 337. Servo motor-generator, parts identified.

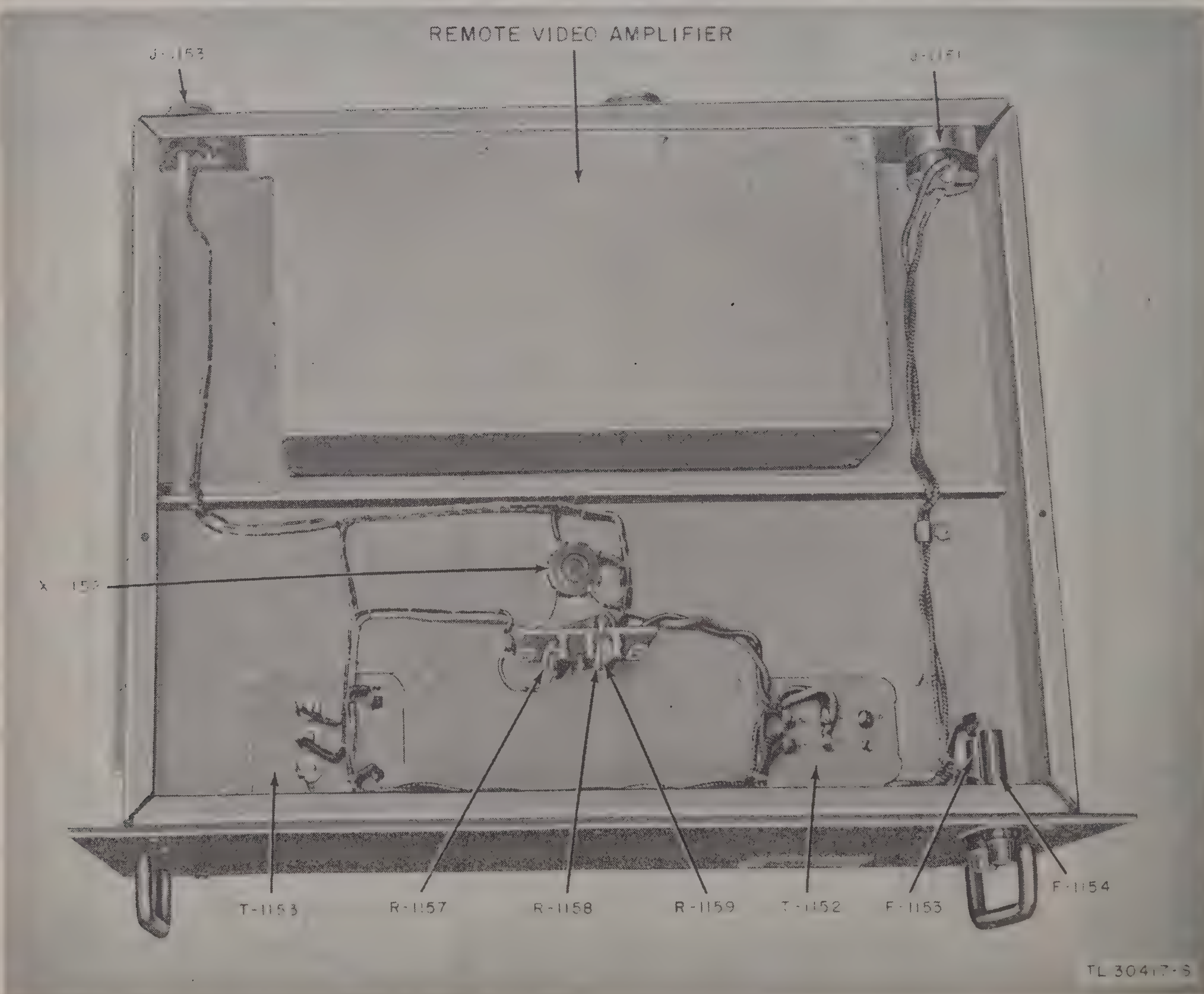


Figure 338. Field power supply, bottom view, parts identified.

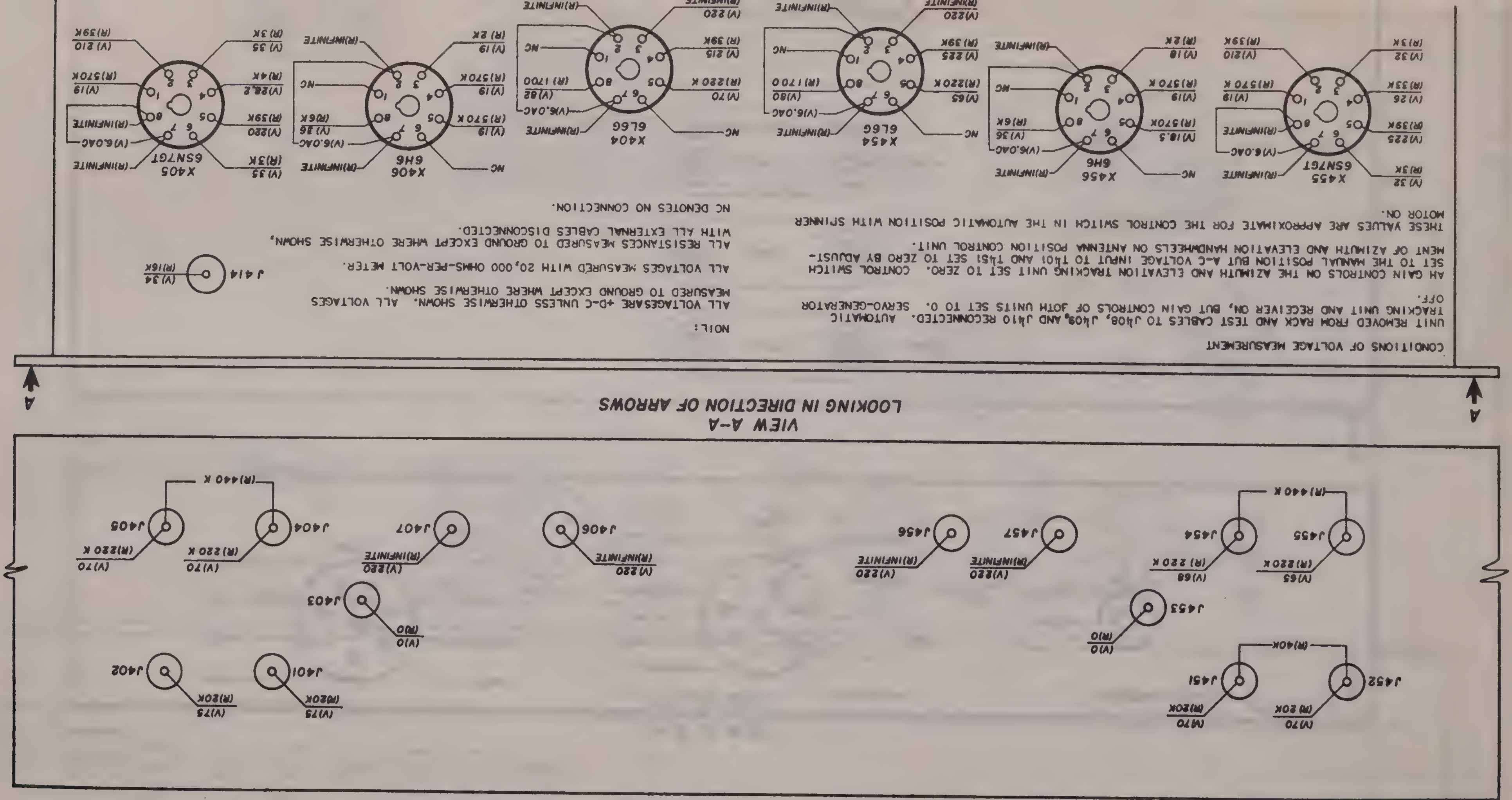


Figure 340. Azimuth and elevation tracking unit, voltage and resistance chart.

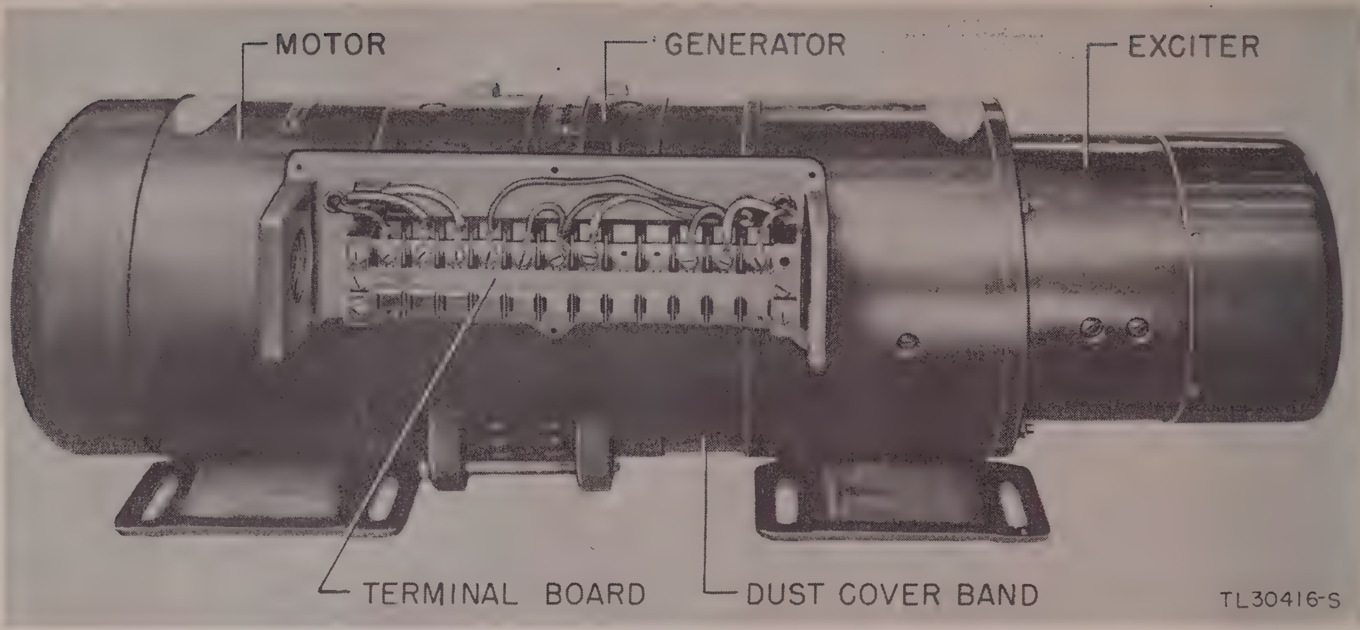


Figure 337. Servo motor-generator, parts identified.

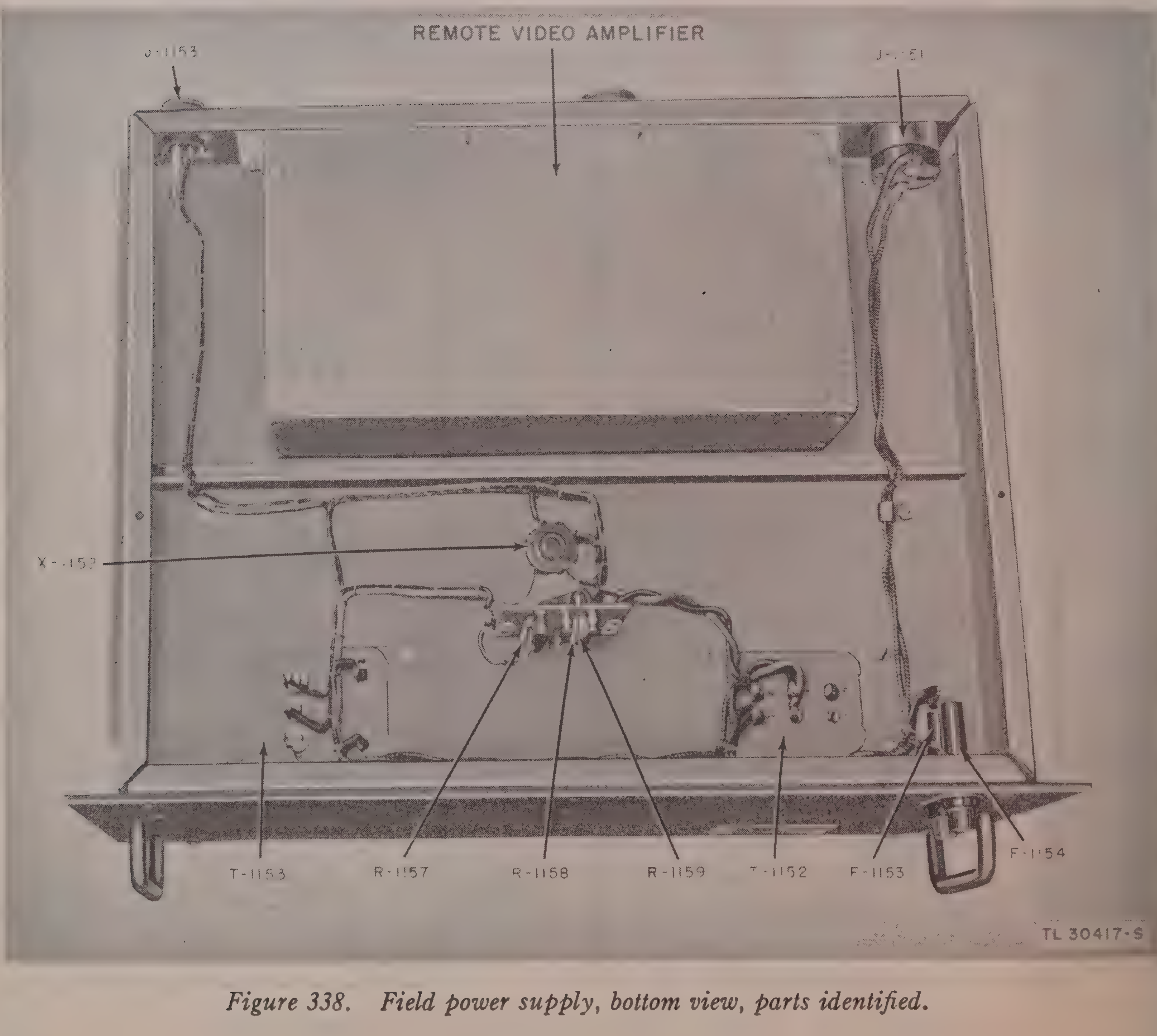


Figure 338. Field power supply, bottom view, parts identified.

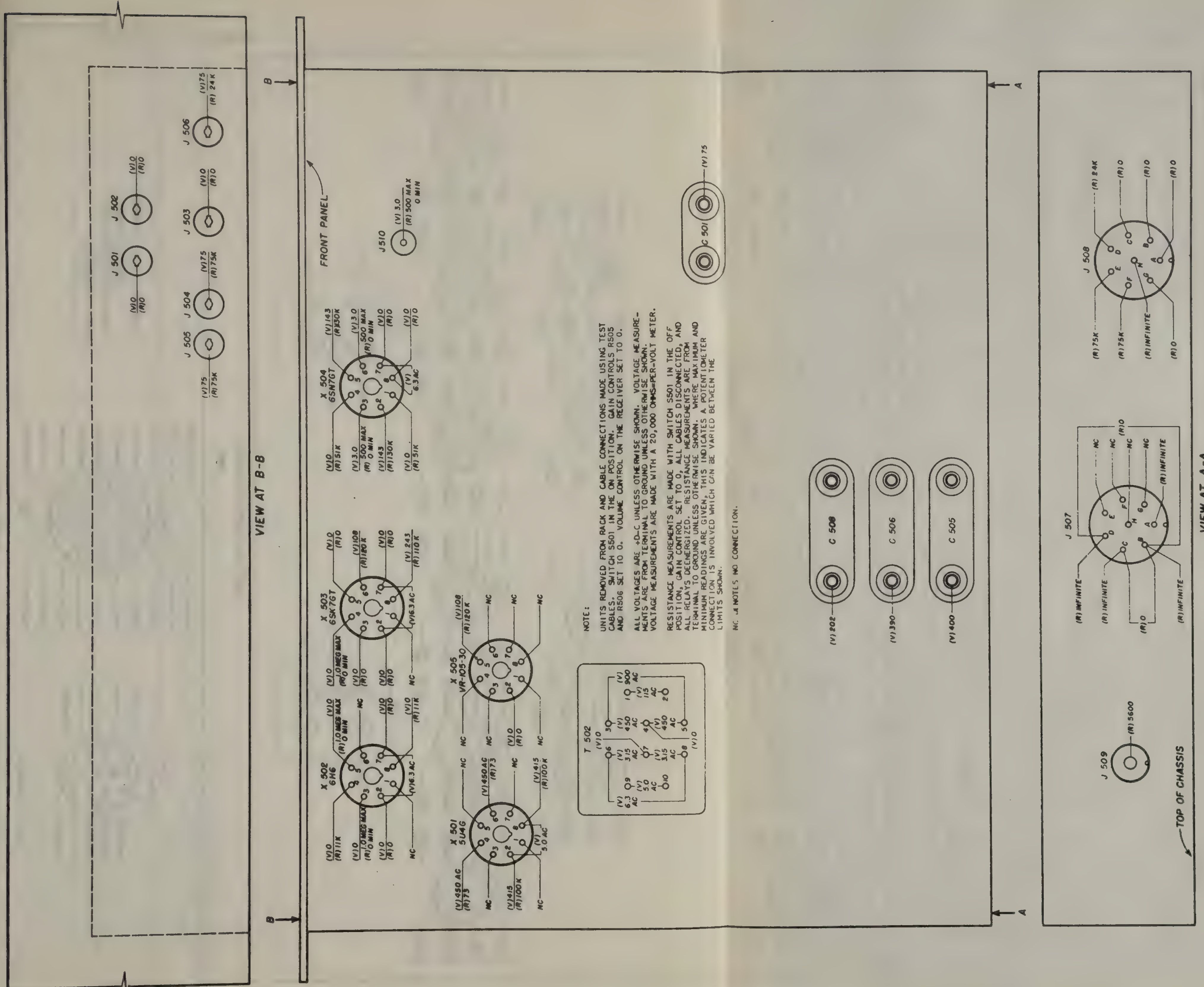


Figure 330. Automatic tracking unit, voltage and resistance chart.

Figure 339. Automatic tracking unit, voltage and resistance chart.

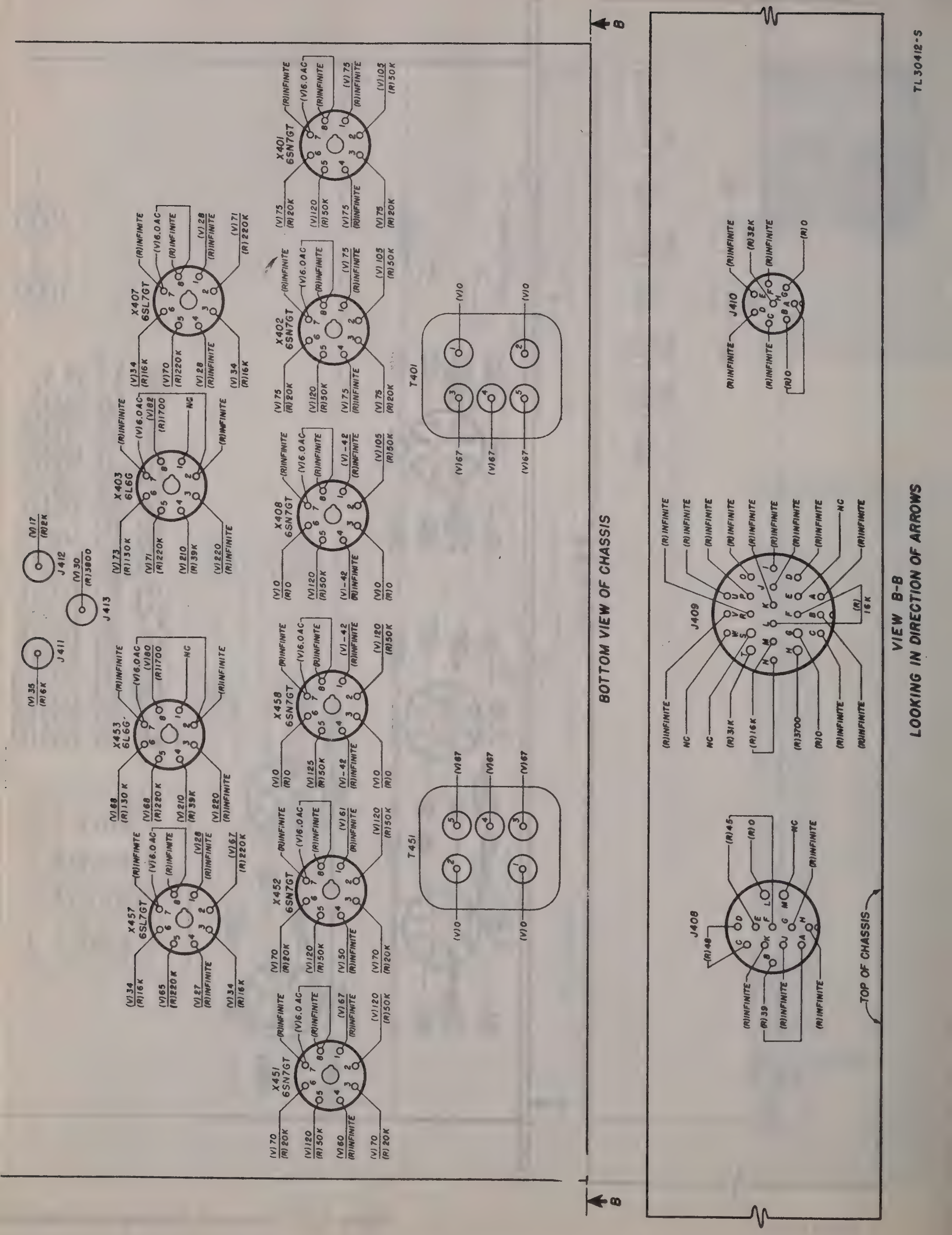


Figure 340. Azimuth and elevation tracking unit, voltage and resistance chart.

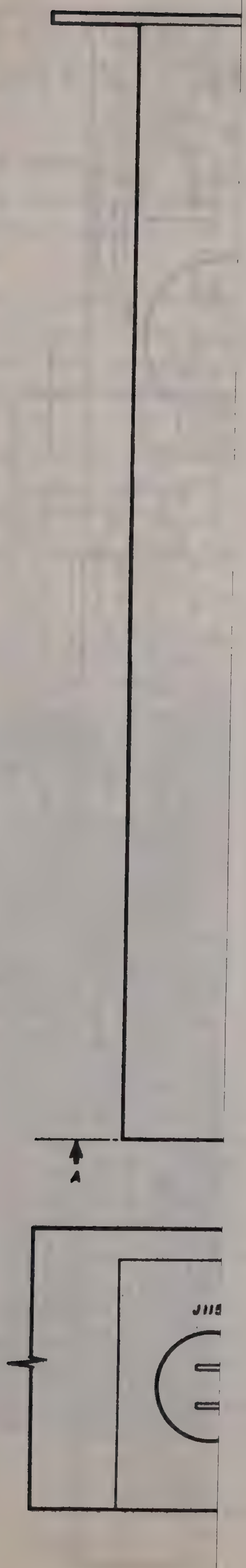


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Figure 340. Azimuth and elevation tracking unit, voltage and resistance chart.

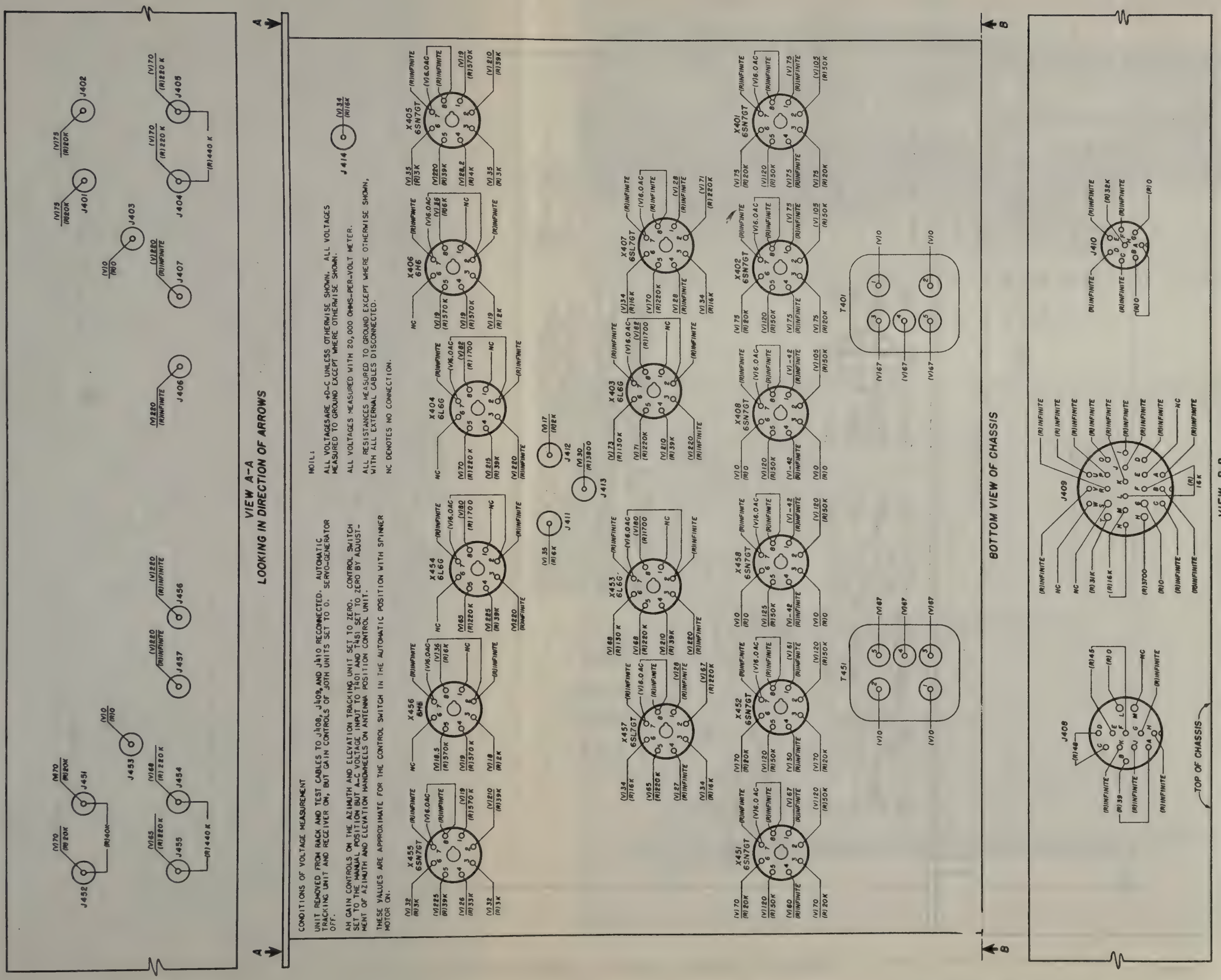


Figure 340. Azimuth and elevation tracking unit, voltage and resistance chart.

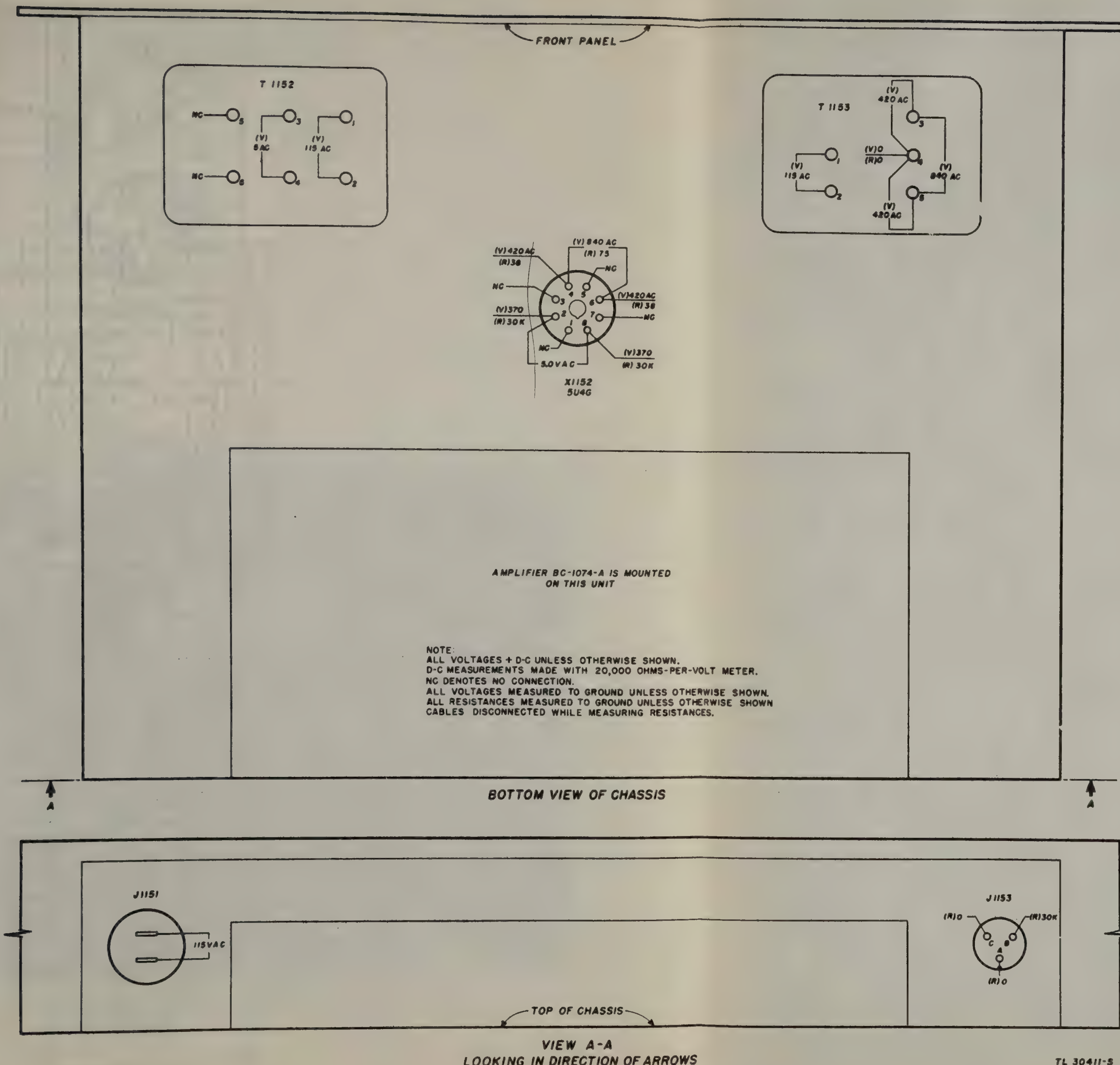
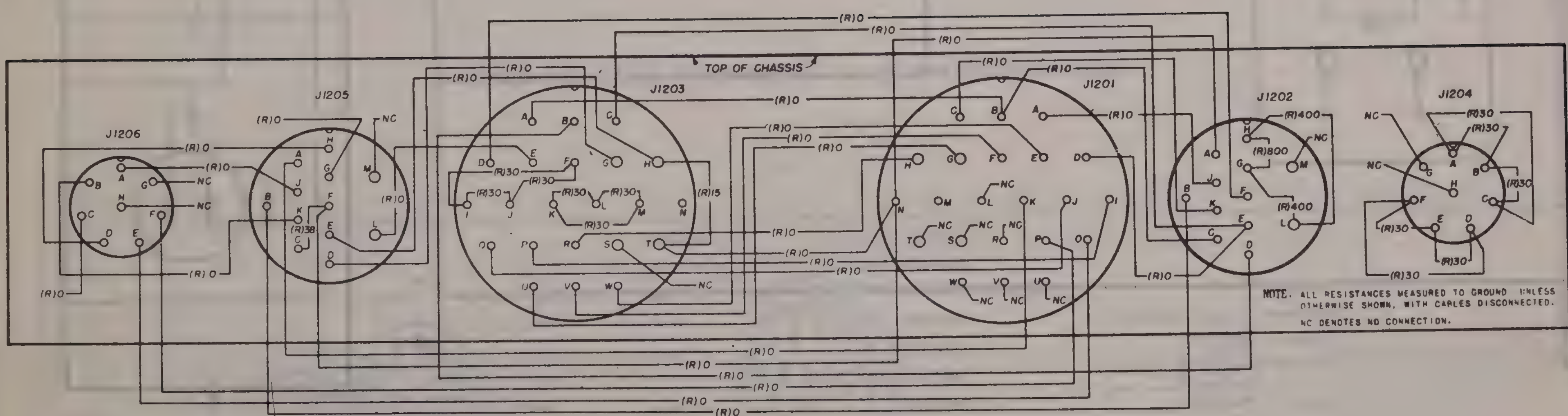


Figure 341. Field power supply, voltage and resistance chart.

Figure 341. Field power supply, voltage and resistance chart.



REAR VIEW

TL 30413-S

Figure 342. Antenna position indicator unit, voltage and resistance chart.

CHAPTER 19

TROUBLE SHOOTING IN THE DATA TRANSMISSION SYSTEM

299. REFERENCE DATA.

The following figures will assist the trouble shooter in locating trouble in the data transmission system.

a. Figure 260. Control circuits, schematic diagram.

b. Figures 255, 256, and 257. Schematic circuit diagrams of the altitude converter system.

c. Figures 343, 346, 347, and 348. Location of components in the pedestal and altitude converter system.

d. Figures 344, 345, and 349. Voltage and resistance charts.

300. GENERAL INFORMATION.

a. The SCR-784 will ordinarily be used with an M9 or M10 gun director, so that the most critical troubles in the data transmission system will be in the potentiometers and associated wiring. This type of trouble shooting consists of continuity and resistance checks made with an ohmmeter with the aid of the major operating and control circuits of the SCR-784 (fig. 260).

b. Trouble shooting in the selsyn data transmission components consists largely of continuity tests. Symptoms refering to trouble in selsyns apply to data selsyns throughout the system. Continuity checks are made with the aid of figure 260.

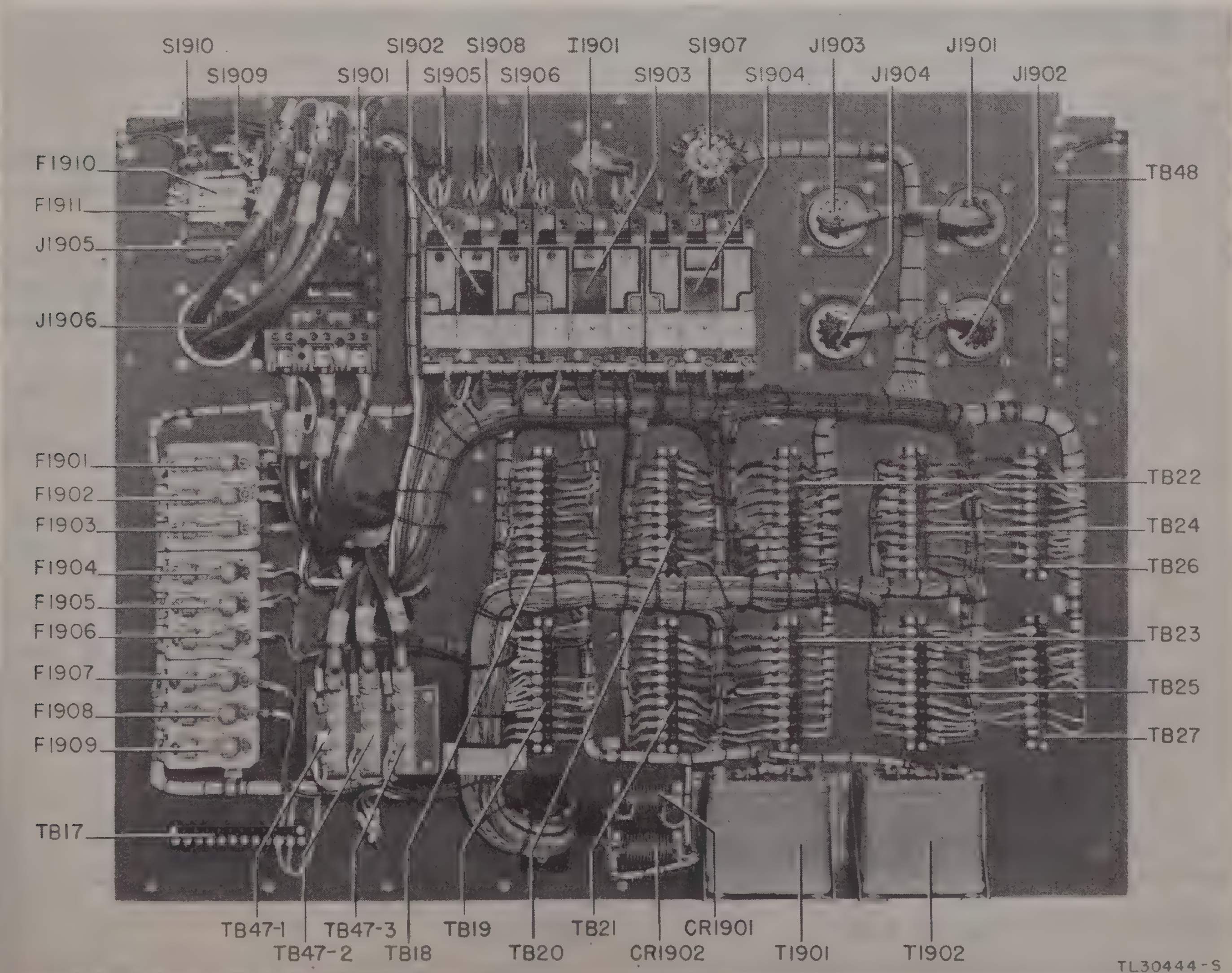


Figure 343. Switch and data panel, rear view, parts identified.

c. When the SCR-784 is used with the M4 or M7 gun directors, trouble may develop in the altitude conversion system. From the operating position, the only external indication of trouble in the system will be the altimeter. If the altimeter does not operate properly, its reading may be checked by comparing its reading with the data unit dial. If they both appear incorrect, the trouble is in the other components of the altitude converter system and not in the altimeter circuit.

(*1*) The action and readings of the dial in the altitude data unit are used in localizing faults in the system. The data unit dial may give incorrect readings, refuse to run, run all the way to either stop, oscillate around the correct reading, or run sluggishly. If the altimeter circuit is functioning normally, these same faults will be apparent on the altimeter.

(*2*) Trouble in the altitude converter unit is localized by signal tracing at the test points with an a-c voltmeter. The symptoms as indicated by the dial on the altitude data unit will indicate which points to check. The alignment procedure gives the proper sequence for tracing the signal through the entire chassis. References are included so that any step that cannot be followed refers to a symptom in the trouble-shooting chart.

d. Symptoms A, B, and C in the trouble-shooting chart deal with faults in the potentiometer data transmission system. Symptoms D through G are faults common to all selsyns and are all checked in the same manner. Symptoms H through M deal with the altitude converter system which is used with the M4 or M7 gun directors.

301. DATA TRANSMISSION SYSTEM, TROUBLE-SHOOTING CHART.

A. SYMPTOM: Jerky or erratic range, elevation, and azimuth data at the director.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. –350-volt supply at director.	1. Remove cable D from switch and data panel and check for a constant –350 volts between pin 9 and ground.
2. Cable connections.	2. Ground terminals on top of range unit and check for zero ohms resistance between terminals 9 and 19 of jacks J1903 and J1904 and ground.
3. Range potentiometer.	3a. Disconnect all connections at the terminal block on top of the range unit. *b.* Connect an ohmmeter between terminals A and L. *c.* The resistance should increase smoothly from 10,000 ohms to 30,000 ohms as the range is decreased. *d.* If the resistance varies in a jerky fashion when step *c* has been repeated several times, change the potentiometer oil as outlined in TM 11-1454. *e.* Replace potentiometer.

B. SYMPTOM: Jerky or erratic elevation and azimuth data at the director.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Elevation data cables or connections to gun directors.	1*a.* Ground terminals 1, 3, 5, 7, 9, and 11 at TB7 in elevation selsyn compartment.

b. Check for zero ohms between terminals 3, 8, 11, 12, 13 of J1904 and ground with the ALTITUDE-SLANT RANGE switch in the SLANT RANGE position.

c. Check continuity.

2. Elevation potentiometer.

2*a*. Disconnect all external connections from terminal block TB7 and measure the resistance between terminals 2(B) and 3(G) as the elevation is changed from its minimum to maximum value. The resistance should vary smoothly from about 4,000 ohms at the minimum elevation setting, to almost zero and then smoothly increase to a maximum of approximately 15,000 ohms at the maximum elevation.

b. If resistance does not vary smoothly see step *f* below.

c. Measure the resistance between terminal 11(B1) and 7(–D) of TB7. This resistance should be approximately 7,500 ohms.

d. Set the potentiometer to the lowest elevation setting and measure the resistance between terminals 11(G1) and 5(R) of TB7 as the elevation angle is increased. The resistance should remain at approximately 17,500 ohms up to zero elevation and then smoothly decrease to 10,000 ohms at +1600 angular mils elevation. If resistance does not vary smoothly see step *f* below.

e. Check resistor R7 for resistance by measuring the resistance between terminal 5(R) and 7(–D) of TB7 as the elevation is decreased, so that the resistance measurement is a minimum. This minimum resistance should be 10,000 ± 100 ohms. Check R8 for the same value by measuring resistance between terminals 1(H) and 3(G) of TB6. Before replacing these resistors, which are high precision units, check the meter by measuring several spare resistors of the same type.

f. Faulty operation of the potentiometer is indicated by the resistance changing in a jerky fashion instead of smoothly with the elevation settings in steps *b* and *d*. If this condition continues after steps *b* and *d* have been repeated several times change the potentiometer oil, following the procedure outlined in TM 11-1454.

g. If changing the oil does not remove the trouble, the potentiometer must be replaced.

C. SYMPTOM: Jerky or erratic azimuth data at the director.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Azimuth data cables and connections to gun directors.	1. Using figure 260 check the continuity of the cable connections to the switch and data panel by grounding terminals 1, 5, 7, and 9 at TB6 and checking for zero resistance between pins 6, 7, 16, 17, and ground at J1904 on switch and data panel.
2. Azimuth potentiometer.	2*a*. Remove all external connections to terminal block TB6.
	b. Check the 10,000-ohm resistor R1 by measuring the resistance between terminals 5(–Y) and 7(–R) of TB6 as the reflector is rotated.
	c. A minimum resistance should be obtained of 10,000 ohms ± 100 ohms. If the minimum resistance is not within these limits, the potentiometer dust cover should be removed and resistor R1 checked directly at its terminals. Resistor R1 is a precision resistor and much more accurate than 10,000 ohms ± 100 ohms. This figure, however, represents the accuracy of the analyzer. Before replacing this resistor, check the meter by measuring several of the same type resistors obtained from spare parts.
	d. Check the 10,000-ohm resistor R2 by the method of step 3 except measure resistance between terminals 1(–X) and 3(G) of TB6.
	e. Strap terminals 9(+R), 3(G), and 7(–R) of TB6 together. Connect test meter between these strapped terminals and the terminal 1(–X) of TB6. Check the potentiometer by rotating the reflector in azimuth slowly. The reading of the resistance should rise and fall uniformly between approximately 10,000 ohms and 17,500 ohms, if proper contact is being made between the potentiometer brush and the winding.
	f. Disconnect meter from terminal 1 and connect to terminal 5(–Y) of TB6 and repeat the above test.
	g. If the meter does not indicate a uniform change in resistance after tests 5 and 6 have been repeated several times, change the potentiometer oil, following the procedure given in TM 11-1454.
	h. If changing the oil does not remove the trouble, the potentiometer must be replaced.

D. SYMPTOM: Receiving selsyn at director rotates in wrong direction when SCR-784 reflector is turned.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Reversed stator leads.	1. The following are the most convenient points at which to make the changes: Az Course — TB21-6 and -7 on switch and data panel. Az Fine — TB24-6 and -7 on switch and data panel. El coarse — TB22-4 and -5 on switch and data panel. El Fine — TB22-1 and -2 on switch and data panel. Altitude — TB61-1 and -3 in altitude data unit.

E. SYMPTOM: Erratic movement of receiving selsyn, operates first in one direction and then in other direction as reflector is rotated continuously in one direction.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Stator coils open.	1. Check resistance of stator coils.
2. Lead to stator coils open.	2. Check continuity and resistance of wiring to stator coils.

F. SYMPTOM: Sluggish or erratic following of selsyns but in correct direction.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Rotor coil open.	1. Check resistance of rotor coil.
2. Connection to rotor coil open.	2*a*. Check slip rings and brushes. *b*. Check continuity and resistance of wiring to rotor coil.

G. SYMPTOM: Receiving selsyn "freezes" in one position.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Stator connections.	1. Check for short on two stator wires. (Selsyns will also overheat.)

H. SYMPTOM: Erratic or jerky operation of altitude dial and altimeter with the ALTITUDE-SLANT range switch on the indicator control panel in either position.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Oscillator V1401 or amplifier V1402 in altitude converter unit.	1*a*. Check voltage at test 2 to be constant at 25 volts ac with no fluctuation. *b*. Check tubes V1401 and V1402 by replacing. *c*. Check capacitor C1403 for open circuit.

	d. Make a voltage and resistance check on these stages (fig. 344).
2. Range potentiometer	2. Check range potentiometer as described in symptoms A, fault 3.
3. Isolation amplifier V1403.	3*a.* Check voltage at TEST 3 with range dial at about 28,000 yards to be 40 ± 3 volts ac.
	b. Check vacuum tube V1403 by replacing.
	c. Make a voltage and resistance check on the stage.
4. Cable connections.	4. Check continuity of cables from altitude converter unit.

I. SYMPTOM: Erratic or jerky operation of altitude dial and altimeter with ALTITUDE-SLANT range switch in ALTITUDE position.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Elevation potentiometer.	1*a.* Place the altitude converter in operation.
	b. Set switch to ALTITUDE and the range to 28,000 yards.
	c. With the test meter, measure the voltage across terminals 3(G) and 7(D) on TB7. This voltage should be approximately 40 volts ac.
	d. Starting at zero elevation and with the test meter connected between terminals 2(B) and 3(G) of TB7 slowly increase the elevation. At zero elevation the voltmeter should read approximately zero and smoothly increase to approximately 40 volts as the elevation is slowly and smoothly increased to +1600 mils. If voltage change is not smooth, see step *f.*
	e. Erratic operation of the potentiometer is indicated by the reading of the voltmeter rising irregularly with smooth increase in elevation. If this condition is encountered, step *d* should be repeated several times and if still erratic change the potentiometer oil in accordance with the procedure in TM 11-1454.
	f. If changing the oil does not remove the trouble, the potentiometer must be replaced. The procedure for replacing the elevation potentiometer is given in Part III.
2. Cable connections.	2. Trace the cable connections with an ohmmeter and figure 260.

J. SYMPTOM: Altimeter and altitude dials do not move.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Defective power supply.	1*a.* Check voltage at test 4 to be 300 volts; if not, see below.

	b. If voltage is too low, check tubes V1451 through V1456 by replacing. *c*. Make a voltage resistance check of these stages (fig. 345).
2. Phase shifter V1402.	2*a*. Check for output at TEST 1. *b*. Replace tube. *c*. Make voltage and resistance check (fig. 344).
3. Field amplifier V1457 and V1458.	3*a*. Check output at TEST 6 for 15 volts ac. *b*. Check tubes by replacing. *c*. Make voltage-resistance check of the two stages.
4. Summing amplifier V1404, V1405, V1406.	4*a*. Check output at test 5 to vary from 0 to 18 volts ac as range is increased to 10,000 yards with ALTITUDE-SLANT RANGE switch on indicator-control panel in SLANT RANGE position. *b*. If no output, check tubes V1404, V1405, and V1406 by replacing. *c*. Make a voltage resistance check of these stages (fig. 344).
5. Altitude-slant range switch S1402 or S1795.	5*a*. Check action of switches. *b*. Check control circuit of K1401 and S1795.
6. Spinner motor.	6*a*. Check resistance across terminals 3 and 4 on TB60 to be 8 ohms with external connections removed. *b*. Measure resistance across terminal 5 and 6 of TB60 to be 8 ohms with external connections removed and the dial in its midposition. *c*. Replace altitude spinner motor B1491 if the above results are not obtained.

K. SYMPTOM: Dial or altimeter runs to either extreme.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Height potentiometer.	1*a*. Check for input to summing amplifier at J1402 from height potentiometer with a-c voltmeter. *b*. Check continuity between terminals 7, 8, and 9 on TB60 (fig. 349).
2. Input to summing amplifier and jack J1404.	2. Make continuity and resistance checks of cabling to elevation potentiometer.

L. SYMPTOM: Dial or altimeter oscillates around the correct reading.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Network Z1402.	1*a*. Check Z1402 by replacing. *b*. Make voltage and resistance check of summing amplifier stages (fig. 344).

M. SYMPTOMS: 1. No altitude indication on altimeter.
2. Altitude dial reads normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. V1976, V1752, V1751.	1*a*. Check tubes by replacing. *b*. Make voltage and resistance checks each stage (fig. 336).
2. Meter M1754	2*a*. Check meter and associated resistors. *b*. Replace meter if defective.

302. ADJUSTMENTS AND ALIGNMENT.

a. Elevation Potentiometer Zero Adjustment. The elevation potentiometer is adjusted at the factory so that it transmits zero elevation when the reflector axis is horizontal and further adjustment is made to match the director during the orientation. If the potentiometer is removed or replaced the following procedure should be followed to obtain the correct zero position.

(*1*) Before the potentiometer is mounted on the pedestal, set the arm to zero by connecting an ohmmeter to terminals B and G and rotating the gear to obtain the minimum resistance reading (approximately zero ohms).

(*2*) Level the pedestal accurately with the leveling jacks, using the levels mounted on the pedestal yoke.

(*3*) Level the reflector mounting by using a gunner's quadrant or spirit level on the specially milled leveling surface.

(*4*) Set the elevation orientation adjusting arm near its midposition by using the adjusting screws.

(*5*) Mount the potentiometer and connect the wiring.

(*6*) Connect the test ohmmeter to points 2 and 3 of terminal block TB7 (equivalent of terminals B and G of the potentiometers) in the elevation selsyn compartment. Set the ohmmeter to measure resistance of less than 10 ohms. (Be sure that cable D is disconnected and that the switch on the switch and data panel is the SLANT RANGE position.)

(*7*) Using manual operation, set the antenna *below* zero elevation.

(*8*) Observe the ohmmeter and elevate the antenna *very slowly*. The resistance should start high and decrease to a minimum value and then increase again. The minimum point is the zero position of the potentiometer.

(*9*) With the potentiometer at zero, place a level on the milled leveling surface on the reflector mounting. If the antenna is not horizontal (level) the potentiometer is not zeroed.

(*10*) To adjust the potentiometer have the operator adjust the antenna to the level position. Loosen the four mounting bolts of the potentiometer and turn the potentiometer to obtain the minimum resistance indication. Tighten the bolts and recheck steps (8) and (9).

b. Altitude Converter.

(*1*) Set the SLANT RANGE-ALTITUDE switch of the switch and data panel to the ALTITUDE position.

(*2*) Apply power by placing the switch on the altitude converter power supply in the UP position.

(*3*) Place the switch on the altitude converter (left side) in the ALTITUDE position.

(*4*) Measure the plate supply voltage by means of the test meter provided with SCR-784. This is done by setting the test meter for a 300-volt d-c measurement. With the "–" test prod connected to the chassis, insert the "+" test prod in the test jack marked TEST 4. If the voltmeter indicates other than 300 volts, set the voltage to 300 by the adjustment marked VOLTAGE CONTROL on the altitude converter power supply. To make this adjustment, unlock the potentiometer with a wrench, use a screwdriver for the adjustment and then relock with the wrench.

(*5*) With the test meter set to measure 25 volts ac and with one test prod connected to the chassis, insert the other test prod in the test jack marked TEST 2 If the meter does not indicate 25 volts ac, unlock and adjust the oscillator output control marked OSC OUTPUT until the meter indicates 25 volts. As this control is varied, the meter pointer will oscillate for several cycles. Allow the pointer to come to rest before a reading is made. Lock the control.

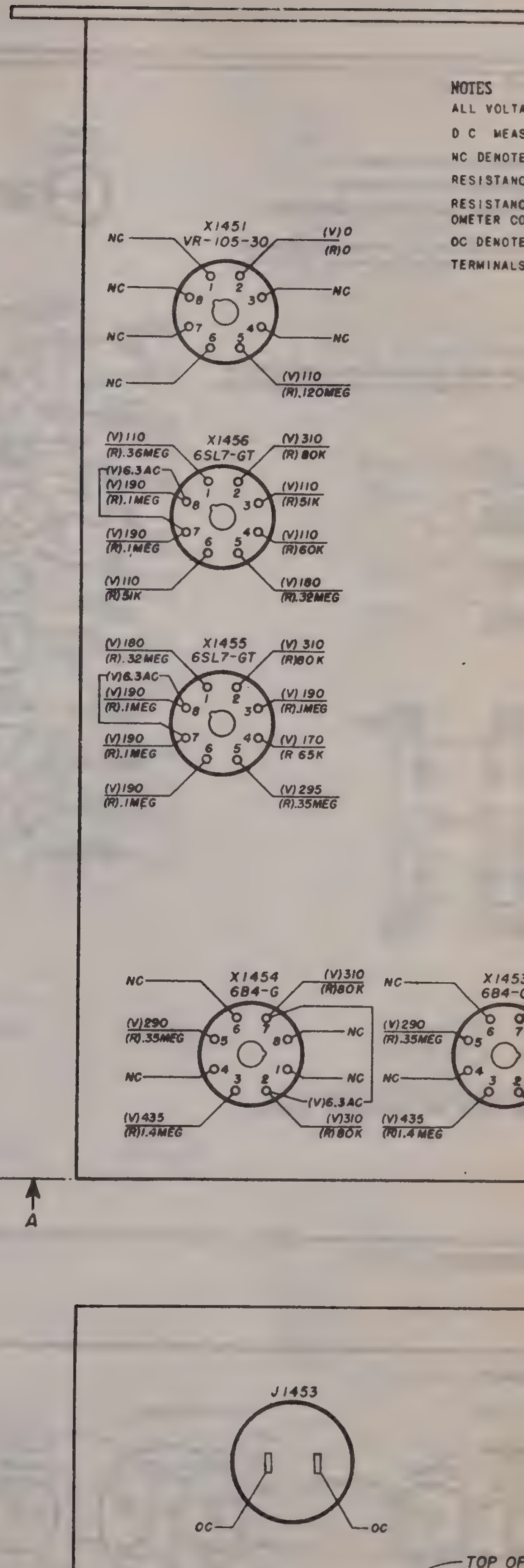


Figure 345. Altitude converter power supply, voltage and resistance chart.

M. SYMPTOMS:	1. No altitude indication on altimeter.
	2. Altitude dial reads normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. V1976, V1752, V1751.	1*a*. Check tubes by replacing. *b*. Make voltage and resistance checks each stage (fig. 336).
2. Meter M1754	2*a*. Check meter and associated resistors. *b*. Replace meter if defective.

302. ADJUSTMENTS AND ALIGNMENT.

a. Elevation Potentiometer Zero Adjustment. The elevation potentiometer is adjusted at the factory so that it transmits zero elevation when the reflector axis is horizontal and further adjustment is made to match the director during the orientation. If the potentiometer is removed or replaced the following procedure should be followed to obtain the correct zero position.

(*1*) Before the potentiometer is mounted on the pedestal, set the arm to zero by connecting an ohmmeter to terminals B and G and rotating the gear to obtain the minimum resistance reading (approximately zero ohms).

(*2*) Level the pedestal accurately with the leveling jacks, using the levels mounted on the pedestal yoke.

(*3*) Level the reflector mounting by using a gunner's quadrant or spirit level on the specially milled leveling surface.

(*4*) Set the elevation orientation adjusting arm near its midposition by using the adjusting screws.

(*5*) Mount the potentiometer and connect the wiring.

(*6*) Connect the test ohmmeter to points 2 and 3 of terminal block TB7 (equivalent of terminals B and G of the potentiometers) in the elevation selsyn compartment. Set the ohmmeter to measure resistance of less than 10 ohms. (Be sure that cable D is disconnected and that the switch on the switch and data panel is the SLANT RANGE position.)

(*7*) Using manual operation, set the antenna *below* zero elevation.

(*8*) Observe the ohmmeter and elevate the antenna *very slowly*. The resistance should start high and decrease to a minimum value and then increase again. The minimum point is the zero position of the potentiometer.

(*9*) With the potentiometer at zero, place a level on the milled leveling surface on the reflector mounting. If the antenna is not horizontal (level) the potentiometer is not zeroed.

(*10*) To adjust the potentiometer have the operator adjust the antenna to the level position. Loosen the four mounting bolts of the potentiometer and turn the potentiometer to obtain the minimum resistance indication. Tighten the bolts and recheck steps (8) and (9).

b. Altitude Converter.

(*1*) Set the SLANT RANGE-ALTITUDE switch of the switch and data panel to the ALTITUDE position.

(*2*) Apply power by placing the switch on the altitude converter power supply in the UP position.

(*3*) Place the switch on the altitude converter (left side) in the ALTITUDE position.

(*4*) Measure the plate supply voltage by means of the test meter provided with SCR-784. This is done by setting the test meter for a 300-volt d-c measurement. With the "–" test prod connected to the chassis, insert the "+" test prod in the test jack marked TEST 4. If the voltmeter indicates other than 300 volts, set the voltage to 300 by the adjustment marked VOLTAGE CONTROL on the altitude converter power supply. To make this adjustment, unlock the potentiometer with a wrench, use a screwdriver for the adjustment and then relock with the wrench.

(*5*) With the test meter set to measure 25 volts ac and with one test prod connected to the chassis, insert the other test prod in the test jack marked TEST 2 If the meter does not indicate 25 volts ac, unlock and adjust the oscillator output control marked OSC OUTPUT until the meter indicates 25 volts. As this control is varied, the meter pointer will oscillate for several cycles. Allow the pointer to come to rest before a reading is made. Lock the control.

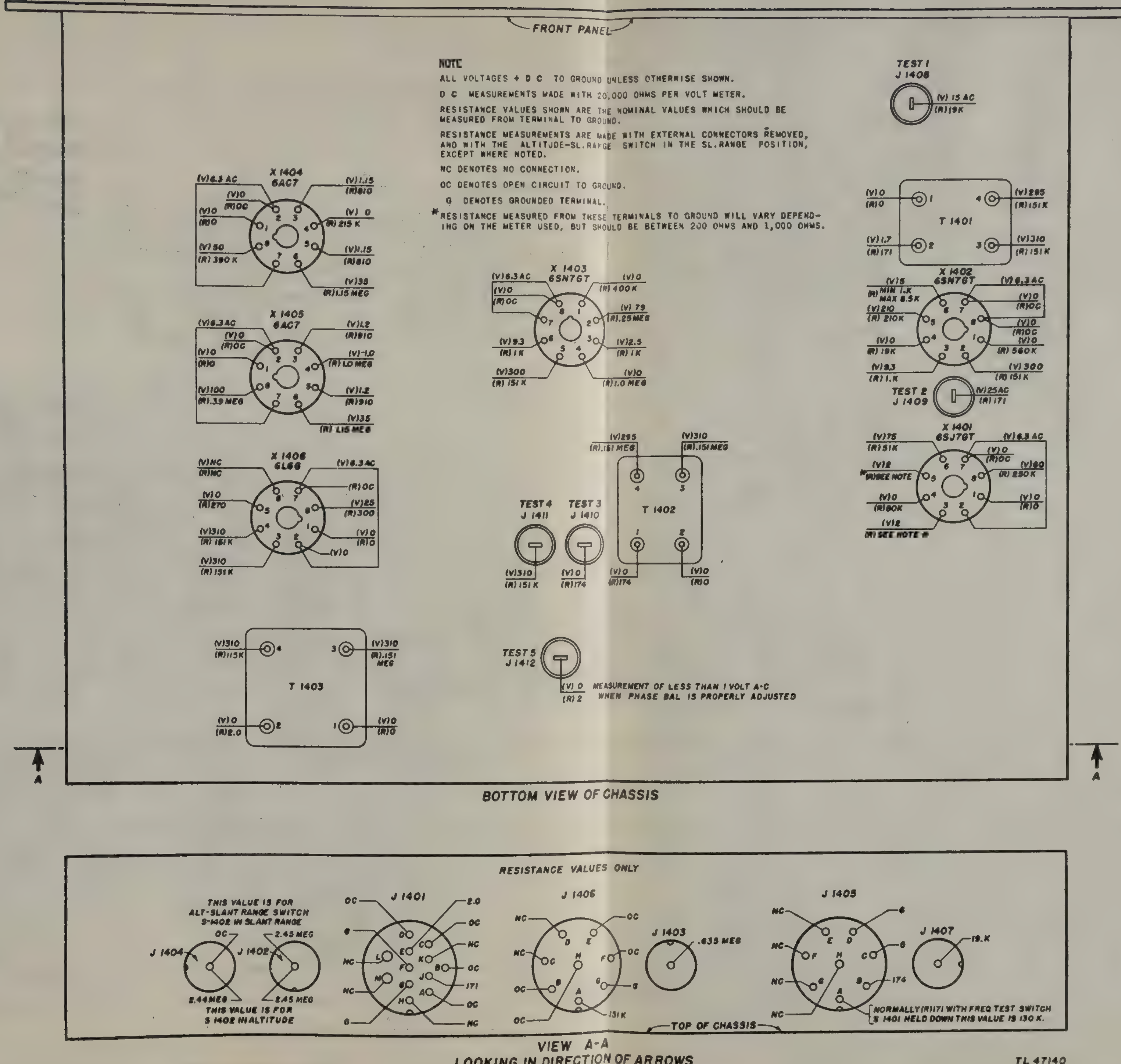


Figure 344. Altitude converter, voltage and resistance chart.

Figure 344. Altitude converter, voltage and resistance chart.

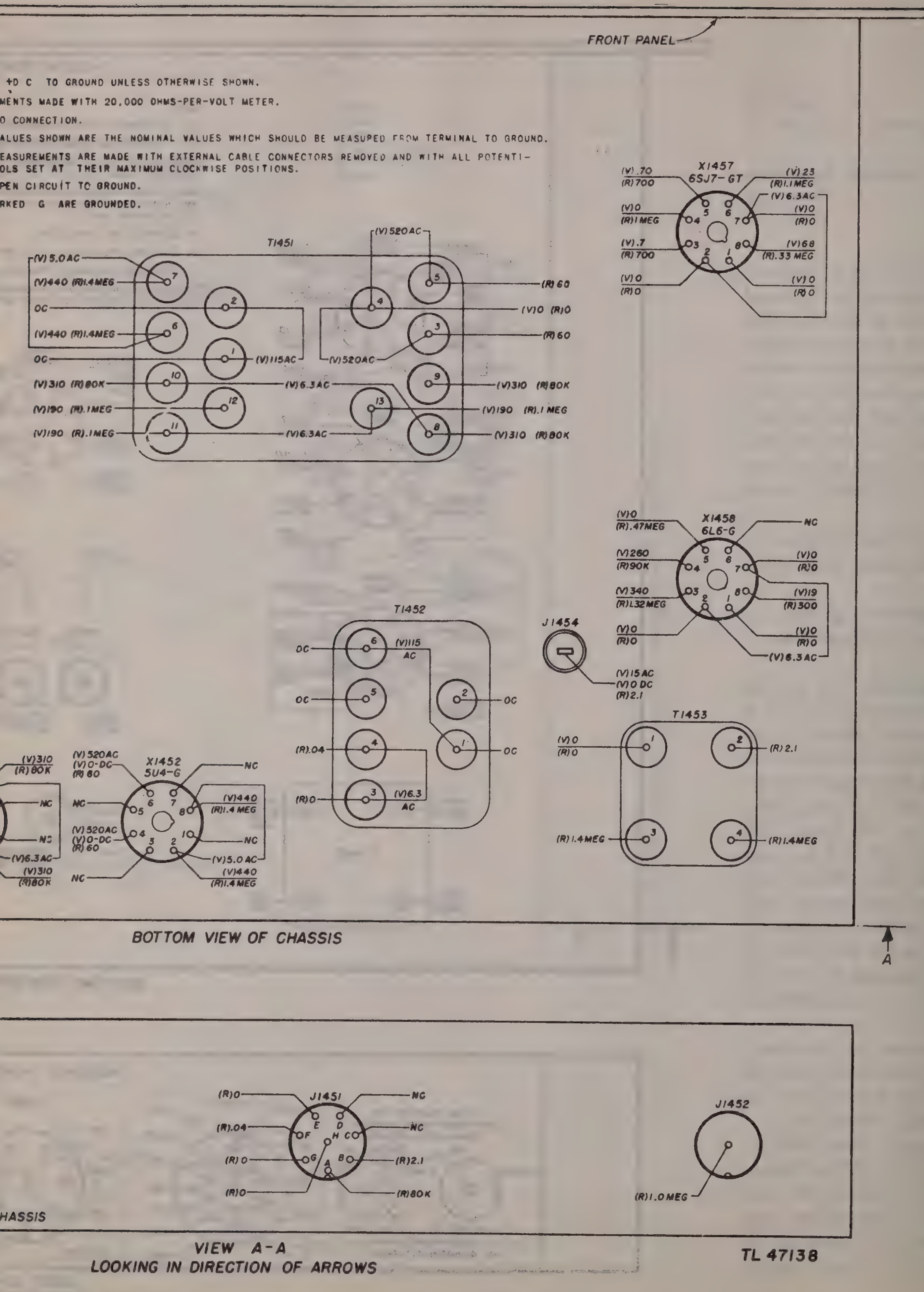


Figure 345. Altitude converter power supply, voltage and resistance chart.

(*6*) Measure the output of the field amplifier by setting the test meter for 15 volts ac, and with one test prod connected to the chassis insert the other test prod in the jack marked TEST 6, on altitude converter power supply. If this voltage is not 15 volts, unlock and adjust the control marked FIXED FIELD V on altitude converter until the meter indicates 15 volts. Lock the control.

(*7*) Set the hairlines of the range indicator unit until a range of approximately 28,000 yards is indicated on the dials.

(*8*) Elevate the antenna by manual control until the index of the antenna poisition indicator unit indicates approximately 360 mils. With the test meter set to measure 40 volts ac, connect one test prod of the meter to the chassis and insert the other test prod in the jack marked TEST 3. If the previous adjustments have been made properly the meter should indicate 40 ±3 volts.

(*9*) Set the range indicator unit until the fine hairlines on its dials indicate 9,000 yards. Place switch S1402 on the altitude converter in the SL RANGE position. The dial on the altitude data unit should indicate approximately 9,000 yards. Depress the elevation of the antenna below zero angular mils by manual control. Operate the FREQ TEST switch of the altitude converter to the down position. This switch is a non-locking switch and it is necessary to hold this switch in the down position.

(*10*) Operate switch S1402 to the ALTITUDE position. If the dial on the altitude data unit moves from its previous position, unlock and adjust the FREQ TEST potentiometer so that the dial does not move. Lock the control. In the above check FREQ TEST switch S1401 should not be allowed to return to its normal position or the motor runs the data unit dial down to 300 yards. It is essential that this

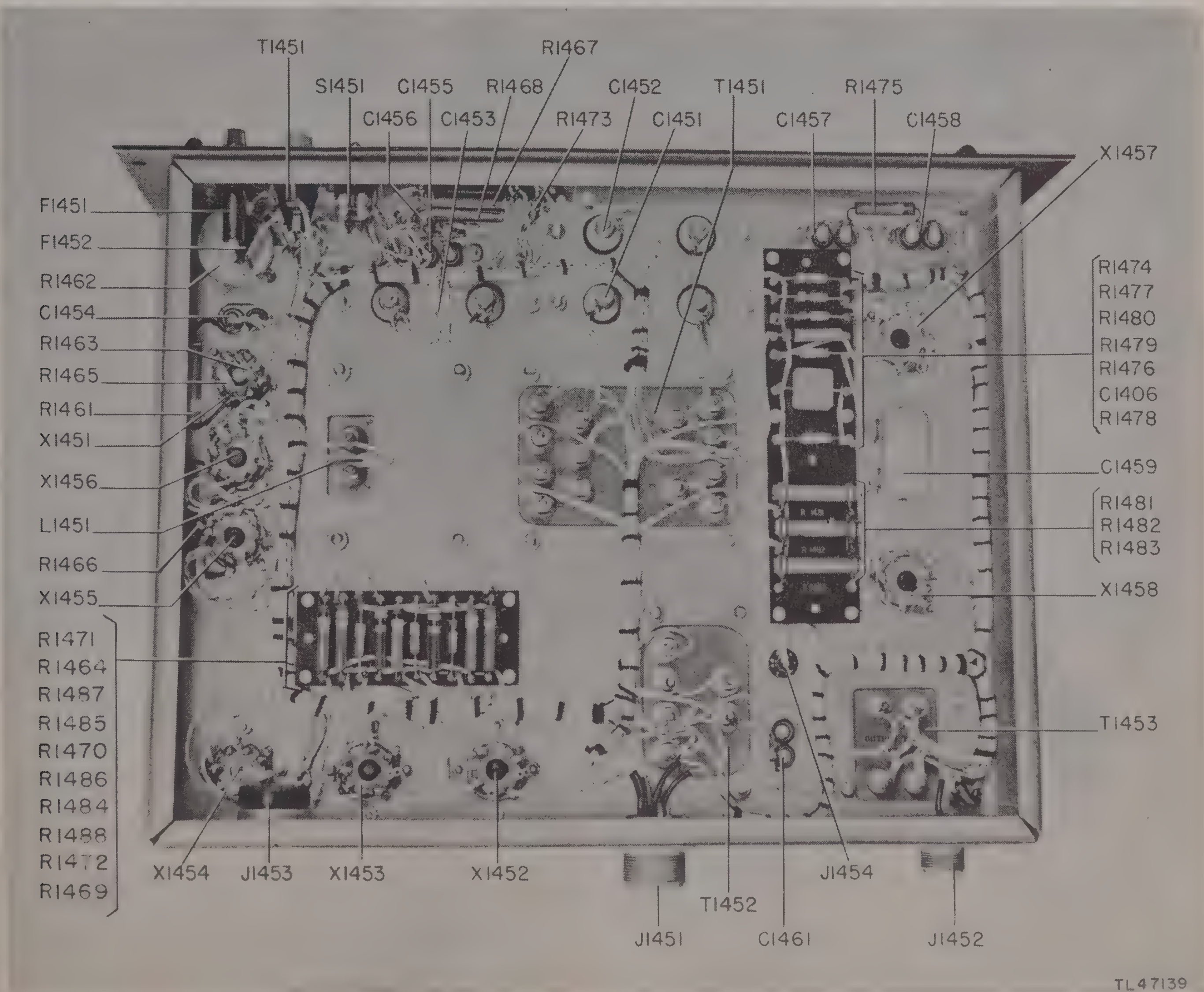


Figure 346. Altitude converter power supply, bottom view, parts identified.

Figure 345. Altitude converter power supply, voltage and resistance chart.

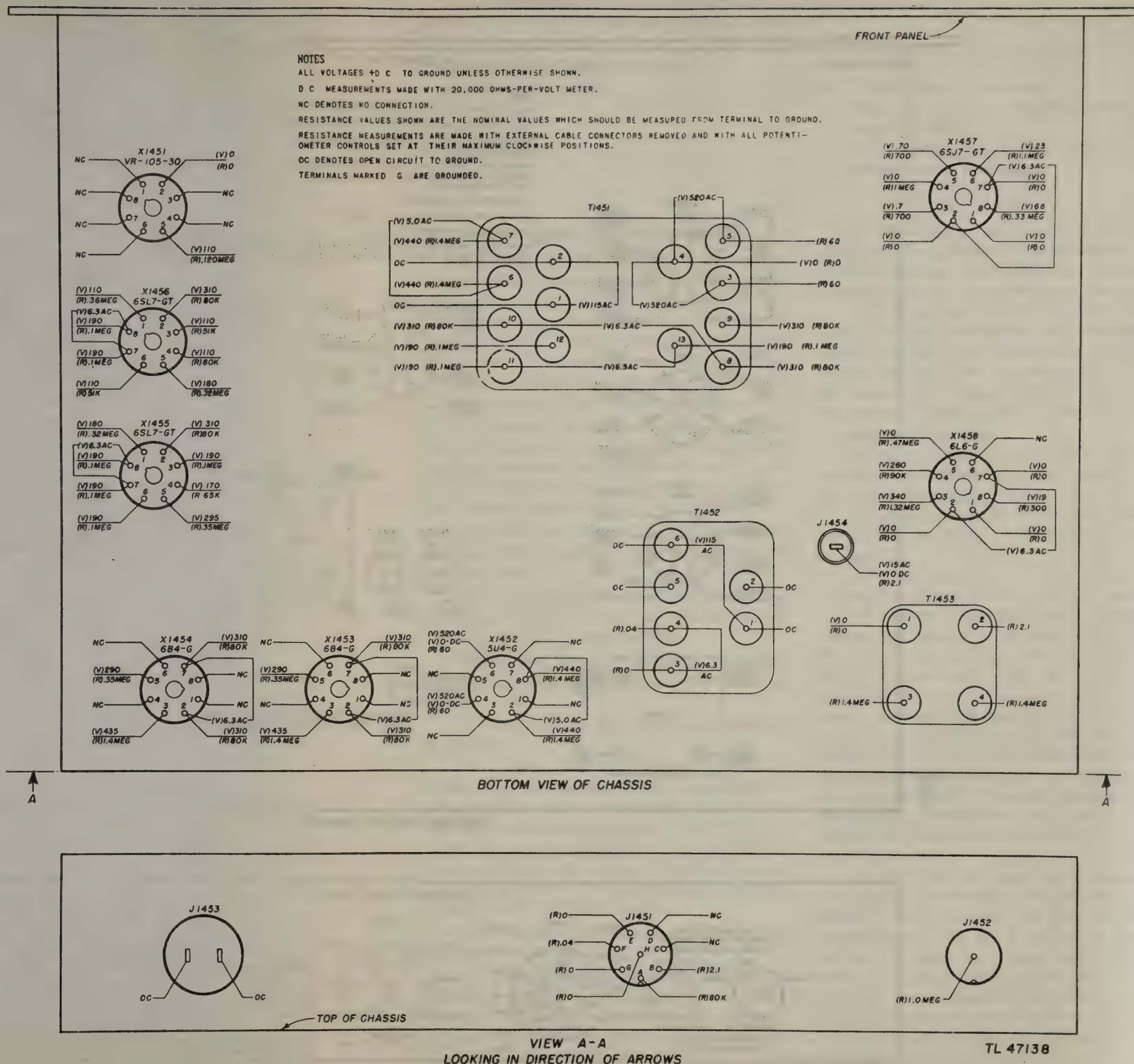


Figure 345. Altitude converter power supply, voltage and resistance chart.

(*6*) Measure the output of the field amplifier by setting the test meter for 15 volts ac, and with one test prod connected to the chassis insert the other test prod in the jack marked TEST 6, on altitude converter power supply. If this voltage is not 15 volts, unlock and adjust the control marked FIXED FIELD V on altitude converter until the meter indicates 15 volts. Lock the control.

(*7*) Set the hairlines of the range indicator unit until a range of approximately 28,000 yards is indicated on the dials.

(*8*) Elevate the antenna by manual control until the index of the antenna poisition indicator unit indicates approximately 360 mils. With the test meter set to measure 40 volts ac, connect one test prod of the meter to the chassis and insert the other test prod in the jack marked TEST 3. If the previous adjustments have been made properly the meter should indicate 40 ± 3 volts.

(*9*) Set the range indicator unit until the fine hairlines on its dials indicate 9,000 yards. Place switch S1402 on the altitude converter in the SL RANGE position. The dial on the altitude data unit should indicate approximately 9,000 yards. Depress the elevation of the antenna below zero angular mils by manual control. Operate the FREQ TEST switch of the altitude converter to the down position. This switch is a non-locking switch and it is necessary to hold this switch in the down position.

(*10*) Operate switch S1402 to the ALTITUDE position. If the dial on the altitude data unit moves from its previous position, unlock and adjust the FREQ TEST potentiometer so that the dial does not move. Lock the control. In the above check FREQ TEST switch S1401 should not be allowed to return to its normal position or the motor runs the data unit dial down to 300 yards. It is essential that this

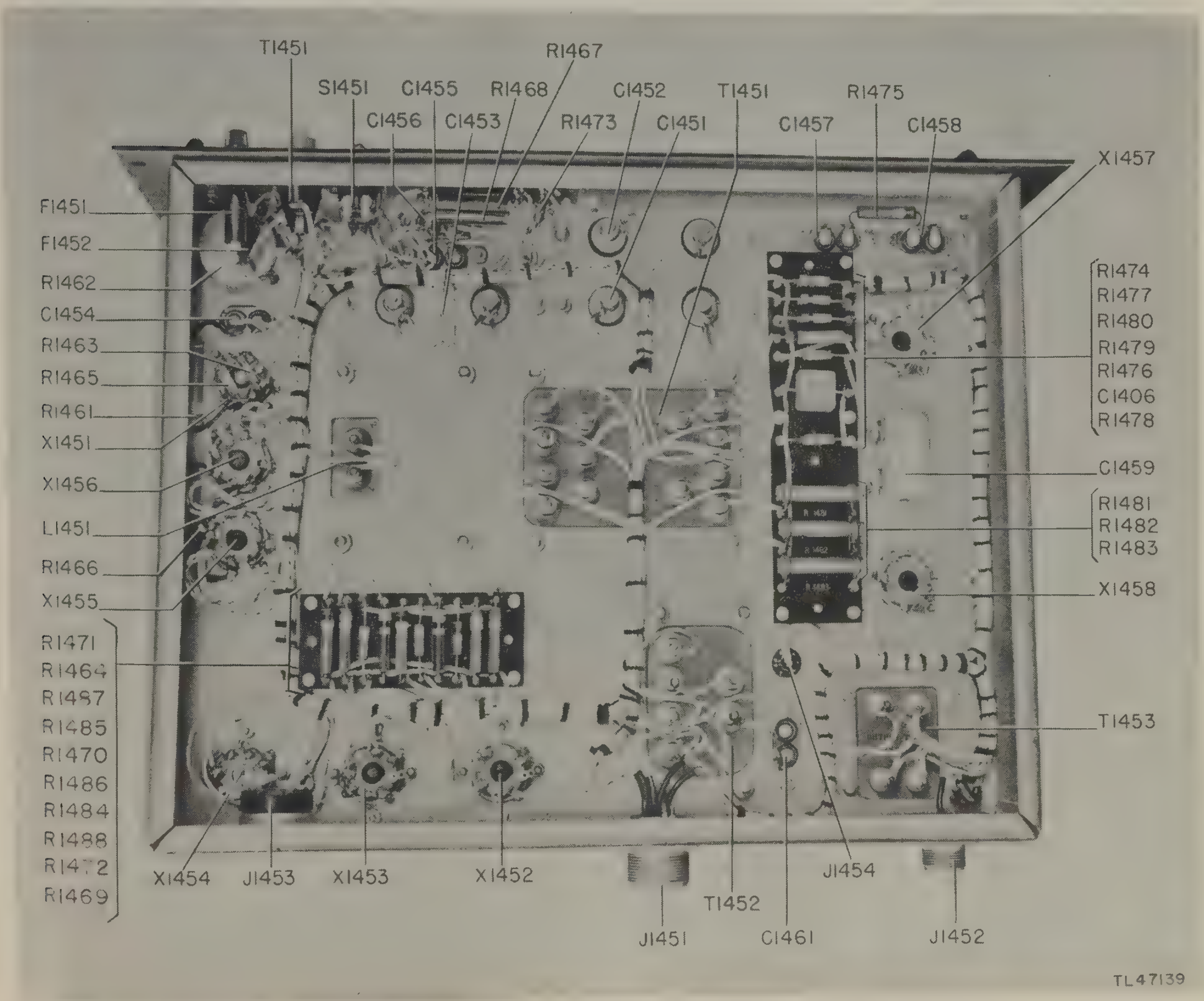


Figure 346. Altitude converter power supply, bottom view, parts identified.

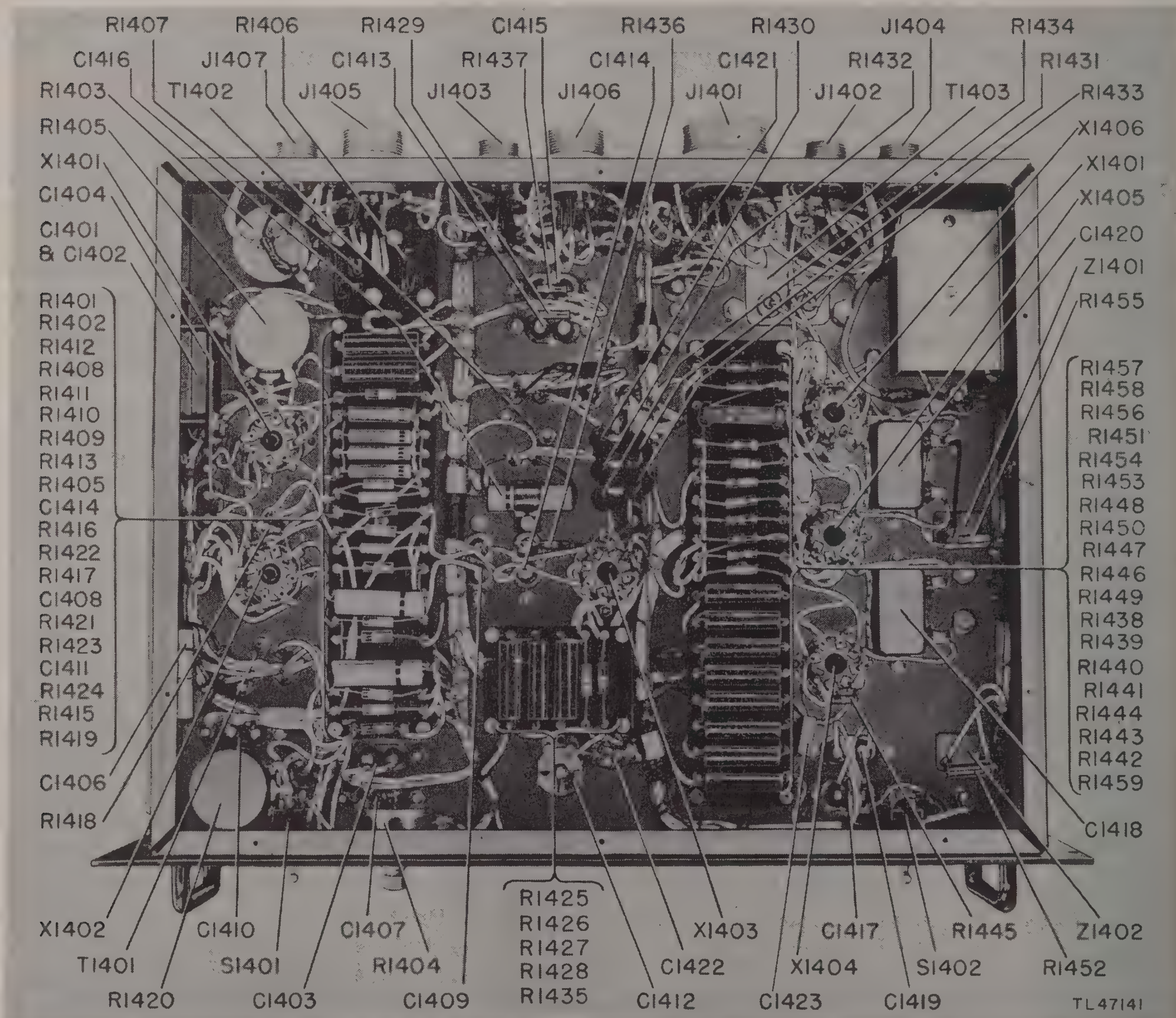


Figure 347. Altitude converter, bottom view, parts identified.

Range dial setting	El dial setting	Pos of ALT-SLANT RANGE switch	Data unit dial should indicate
Below 300 yards, any setting from 300 to 10,000 yards.		SL RANGE	Below 300 yards. Range dial setting ±30 yards.
Any setting from 300 to 20,000 yards.	533.3 ang mils	ALTITUDE	Half range dial settings ±30 yards.
Any setting from 3,000 to 28,000 yards.	346.03 ang mils	ALTITUDE	One-third range dial settings ±30 yards.

check be made with a reading between 7,000 and 9,500 yards on the data unit dial. On the completion of the above test release the FREQ TEST switch S1401 and allow it to return to normal.

(*11*) Set the range dials to exactly 5,000 yards. Place switch S1402 in the SLANT RANGE position. Unlock and adjust the HEIGHT CALIBRATE potentiometer on the altitude data unit until the data unit dial indicates 5,000 yards. Lock the control.

(*12*) The equipment is now in proper adjustment and may be checked by setting the range dials of the range indicator unit to the range, and the elevation dial on the antenna position indicator unit to the various angles as given in the table above.

(*13*) An adjustment is provided on the altitude data unit to synchronize the altitude selsyn with the receiving selsyn in the director. This synchronization is accomplished by turning the shaft with a screwdriver until the altitude dial at the director indicates the same reading of the dial of the altitude data unit.

> **NOTE:** Difficulty will be encountered in setting the elevation exactly 533.3 angular mils or 346.03 angular mils as indicated above, unless a dial in the director (not part of SCR-784) is used. To obtain more accurate settings without a director the following method may be used. To obtain 533.3 mils set 10,000 yards on the range dials and elevate the antenna until the data unit reads exactly 5,000 yards. To obtain 346.03 mils set 18,000 yards and elevate until the data unit reads exactly 6,000 yards. After the setting is obtained the elevation should not be touched but the calculations of the data unit may be checked by varying the range dial setting as indicated in the table.

c. Altimeter. The altimeter is aligned so that its readings agree with the altitude dial on the data unit. After the altitude dial has been calibrated, the altimeter may be most easily calibrated against the range dials.

(*1*) Turn the altimeter ON-OFF switch to the ON position and allow the tubes to warm up.

(*2*) Set the ALTITUDE-SLANT RANGE switch on the indicator control panel to the SLANT RANGE position.

(*3*) Turn the range handwheel so that the range indicated is 300 yards and adjust the BALANCE control for the same reading on the altimeter.

(*4*) Turn the range handwheel so that the range indicated is 9,000 yards and adjust the CALIBRATE control for the same reading on the altimeter.

(*5*) Repeat steps 4 and 5 until the reading on the altimeter agrees with the range indicator at both ends of the scale.

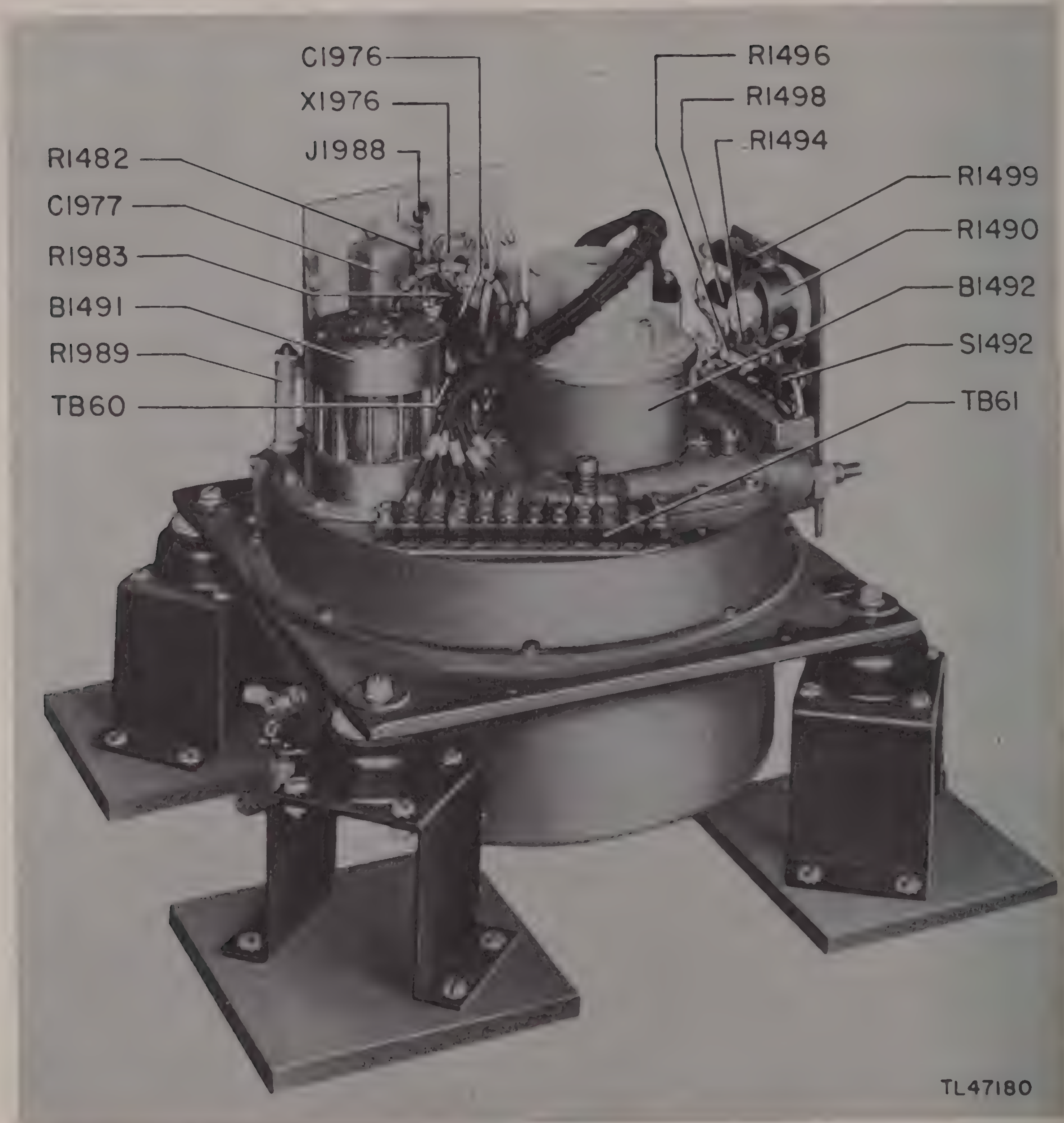
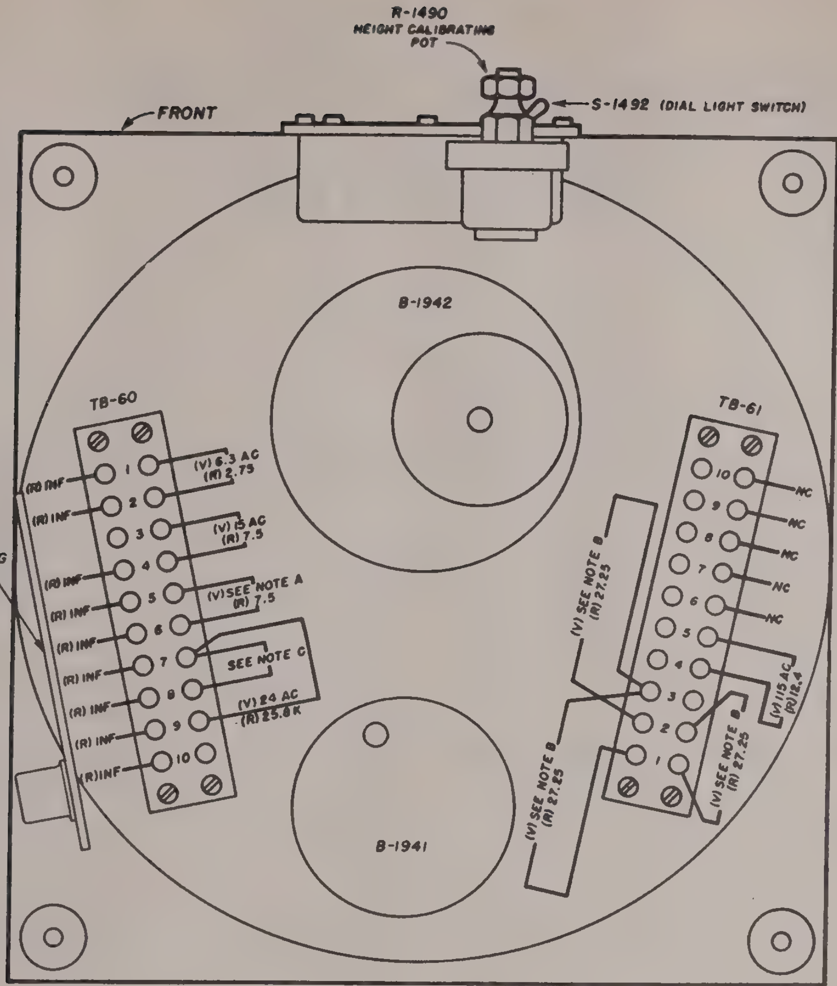


Figure 348. Altitude data unit, parts identified.



NOTE

ALL VOLTAGES MEASURED TO GROUND UNLESS OTHERWISE SHOWN.

ALTITUDE CONVERTER CONTROL UNIT HAS ITS ALT -SLANT RANGE SWITCH, S1402 IN THE SLANT RANGE POSITION.

DIAL LIGHT SWITCH, S1492, IN ON POSITION, AND ADJUSTMENTS MADE FOR NORMAL OPERATION OF SYSTEM.

NC DENOTES NO CONNECTION.

ALL RESISTANCES MEASURED TO GROUND UNLESS OTHERWISE SHOWN, WITH EXTERNAL CONNECTIONS REMOVED.

NOTE A, VOLTAGE BETWEEN THESE 2 TERMINALS VARIES FROM ABOUT 0.5 VOLTS A C (WHEN SPINNER MOTOR IS AT REST) TO ABOUT 25 VOLTS A C THE LATTER OCCURS WHEN MOTOR IS RUNNING DUE TO CHANGING OF RANGE BY TURNING SLEWING HANDWHEEL ON RANGE INDICATOR. (BC-1371).

NOTE B, TB-61 TERMINALS 1-2, 2-3, AND 1-3 VOLTAGE BETWEEN THESE TERMINALS DEPENDS ON RANGE SETTING OF SLEWING HANDWHEEL ON RANGE INDICATOR (BC-1371) MAX 98 V A C MIN 0.

NOTE C, VARIES AS RANGE IS CHANGED BY TURNING SLEWING HANDWHEEL RANGE INDICATOR (BC-1371) MAX (V) 16.0 A C, MIN (V) 3 A C

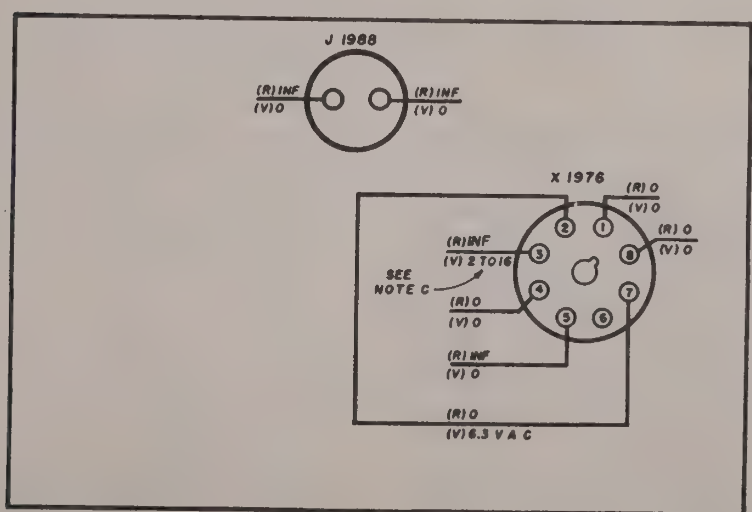


FIG A

TL 47136

Figure 349. Altitude data unit, voltage and resistance chart.

CHAPTER 20
COMPLETE ALIGNMENT PROCEDURE

303. GENERAL.

This chapter has been written to make it possible to use the manual as a guide in overhauling a radar set that is completely out of action, and subsequently in testing it to see that it is operating properly. Not to duplicate information that is contained in other sections of the manual, references are given for more detailed information on any general statement made in this chapter. References are to TM 11-1554 unless otherwise stated. The procedure of overhauling the set should follow the order of paragraphs in the chapter. If trouble develops in a system already aligned and repaired once, the repairman should repair the faulty component and start the overhauling procedure by re-aligning that system and all succeeding systems as outlined.

304. PRELIMINARY MAINTENANCE AND REPAIRS.

The first step in overhauling the set, is to give all components thorough preventive maintenance, using TM 11-1454 as a guide. Since the set should not be started and stopped, it is not possible to perform most of the FEEL operations. Use of the FITCAL system as a preliminary check helps in locating burned-out resistors, broken gears, dirty contacts, blown fuses, shorted transformers, and similar electrical and mechanical troubles. Whenever a part is suspected of being faulty, it should be removed, tested, and if necessary, replaced. Refer to general trouble-shooting procedures, paragraphs 208 to 215 for information on testing parts.

305. UTILITIES.

After the preliminary maintenance and repairs, power should be applied to the unit from the power unit. Make sure that the main power switch on the switch and data panel is in the OFF position. Connect the selsyn excitation jumper cable. Turn on the two main blowers and check them for correct operation. Make repairs if necessary. Turn on the heaters if they are not already operating. Check them for correct operation and make repairs if necessary. If neither the blowers nor heaters operate, check the power input cable and the wiring in the switch and data panel. See paragraph 207. Turn on the trailer lights and make repairs if they do not operate properly.

306. STARTING THE EQUIPMENT.

Place the equipment in operation. Refer to TM 11-1354, paragraph 44, Starting Procedure. If improper indications are observed during the starting procedure refer to paragraph 230, Trouble Shooting Based on the Starting Procedure.

307. CONDITIONS AT START OF ALIGNMENT.

Most of the equipment should be in operating condition, although not necessarily operating properly, before alignment is attempted. The chart on the next page gives the minimum requirements of operating conditions that should be observed on the scopes, meters, and the antenna before starting to align the set. The column to the right gives the paragraph reference for trouble-shooting procedures to be followed whenever the minimum operating requirement is not found.

308. ALIGNMENT OF THE RANGE UNIT.

The basic timing pulses which operate the equipment are generated in the range circuits; therefore, complete alignment procedures should start with the range circuits. If observation of the circular sweeps indicates faulty operation, do not adjust controls haphazardly to correct the fault. Such action may result in throwing other circuits out of adjustment. The alignment procedure, paragraphs 267 to 283, should be followed carefully. No alignment should be attempted on the delay multivibrator or sweep

Indicator	Minimum Indication	References
Line voltage meter; phases AB, BC, CA	114-116 volts ac.	par. 231
Oscillator plate current meter	20-27 ma.	par. 258
Rectifier voltage meter	18-22 kv.	par. 234
Crystal current meter	0.15-0.5 ma.	par. 258
Range scopes	1. Part of sweep trace faintly visible.	par. 265
	2. Main pulse and weak echoes faintly visible.	par. 265
	3. Sweep trace nearly circular, and approximately under scribed line.	par. 265
PPI scope	1. Part of sweep trace faintly visible.	par. 288
	2. Ground clutter and echoes faintly visible.	par. 288
	3. Sweep trace starts nearly at center of scope.	par. 288
Azimuth M. G. field current meters	25-28 ma with the antenna at rest.	par. 296
Elevation M. G. field current meters	25-28 ma with the antenna at rest.	par. 296
Driver plate current meter	12-22 ma.	par. 234
Keyer grid current meter	11-17 ma.	par. 234
The antenna should move when the manual and automatic positioning controls are operated, and the spinner motor should be operating properly.		par. 296

transformers until it is certain that the crystal oscillator is synchronizing the frequency-dividing multivibrators. Refer to paragraph 262. These multivibrators are free running, and could be producing trigger pulses without being synchronized by the crystal oscillator. It has already been determined that the crystal oscillator is operating, since the 2,000-yard range scope sweep is present. If the crystal oscillator is not synchronizing the frequency-dividing multivibrators, the 32,000-yard sweep is highly distorted and unstable. Adjustments and, if necessary, trouble-shooting procedures, paragraph 265, should be carried out on the FOCUS and INTENSITY controls before alignment so as to obtain a clean, moderately bright trace. The switches, paragraph 88, on the back of the receiver, range indicator, and range unit should be set in the NORMAL position while aligning the range unit. After the range unit has been aligned, there should be definite improvement in the sweep traces on the range scopes. The sweeps should extend all the way around the scopes; they should be circular, and they should be exactly between the scribed lines on the scope faces. The range information presented on the scopes is not accurate unless the sweep traces are circular and centered between the scribed lines. Some improvement in the appearance of the transmitted pulse and the target echoes may, or may not, be noted. It should be possible to adjust the length of the 2,000-yard sweep from 100 to 2,000 yards with the NARROW GATE WIDTH control. The range hairlines should indicate range accurately.

309. ALIGNMENT OF THE TRANSMITTING SYSTEM.

The strength of the transmitted pulses, and hence the strength of the returning target echoes, depends upon the operation of the transmitting system. Weak signals may be received on the scopes even though the receiving system is functioning improperly; therefore the transmitting system should be aligned (par. 235) before attempting to align the receiving system. No alignment is possible in the driver. The only alignment procedure in the transmitting system which affects the strength of the transmitted pulses is the magnet field adjustment. A thorough check of the transmitting system for possible causes of weak transmission should accompany the alignment procedure and trouble-shooting procedures, paragraph 234, should be carried out where necessary.

310. ALIGNMENT OF THE RECEIVING SYSTEM.

The general method of receiver tuning, paragraph 259, is to follow the signal in its path from

the antenna to the video stages of the receiver, aligning the various tuned circuits so as to give maximum sensitivity and selectivity. This step is normally made after the transmitter is aligned. The amplitude of the received echo is the basic criterion of receiver performance, but weak echo signals are not necessarily an indication of trouble in the receiver. If the transmitter is known to be functioning properly, and if receiver alignment and trouble shooting fail to bring adequate results, the r-f line should be thoroughly inspected for signs of arcing. Refer to paragraph 243. This involves the removal of the sections in the antenna mount, which are not easily accessible. (See pars. 244 to 245). To prevent wasted time and labor, the repairman should train himself to distinguish the sound of arcing from the normal operating sounds inside the trailer. The receiver should be able to operate on signals of 3 to 8 microvolts and such signals can easily be lost in the r-f line if it is not functioning properly. When receiver alignment is completed, it should be possible to receive strong signals to the maximum range of the 32,000-yard range scope.

311. ALIGNMENT OF THE ANTENNA POSITIONING SYSTEM.

Alignment of the antenna positioning system. (par. 297) should be made next, since all of the systems which have not yet been aligned depend upon correct movement of the antenna for their operation. After alignment is completed, the antenna should track in azimuth and elevation, on manual and automatic operation. The antenna may, or may not, position by remote control since the data transmission system has not yet been aligned. The movement of the sweep line on the PPI scope cannot be used as a reference for azimuth antenna movement since the PPI system has not been aligned.

312. ALIGNMENT OF THE PPI SYSTEM.

The PPI system should first be aligned (par. 289) to give the correct appearance of the sweep line and range markers. Following this, a complete orientation alignment of the PPI sweep line, antenna and elevation indicator dials, and antenna should be made. This alignment assures that the sweep line gives an accurate indication of the relative position of the antenna while the azimuth and elevation indicator dials show accurately the actual pointing direction. Refer to TM 11-1354, paragraph 48, for instructions on making this orientation alignment.

313. ALIGNMENT OF THE RANGE TRACKING CIRCUITS.

Before alignment of the data transmission system can be attempted, it is necessary that the range tracking circuits be aligned (pars. 278 and 279, so that accurate range information may be transmitted. The manual tracking and aided tracking circuits should be aligned first and then the automatic range tracking circuits with the ART-NORMAL switches set to the ART position.

314. ALIGNMENT OF THE DATA TRANSMISSION SYSTEM.

If the set is to be used with a gun director, the data transmission system should be aligned next. Refer to paragraph 302. The orientation alignment made at the end of the PPI system alignment should be checked. It may be found that the orientation as already made does not agree with the indications on the dials on the gun director since these indicator dials are much more accurate than those on the radar set. Refer to TM 11-1354, Appendix A. Where practical, the set should be connected to IFF equipment to see if proper voltages exist at the IFF jacks.

315. CHECKING SET OPERATION.

After the set has been completely aligned, it should be checked by using the log sheet, figure 72, TM 11-1354, as a check list. Refer to the text material of chapter 4, TM 11-1354, for explanations of the OK-N* items. Reference also should be made to paragraph 5 of this manual, TM 11-1554, in which is tabulated the technical specifications that the set would be expected to meet in an acceptance test.

PART THREE
ANTENNA MOUNT MP-61-B

CHAPTER 21
INTRODUCTION

SECTION I
DESCRIPTION

316. GENERAL.

The main structural parts of Antenna Mount MP-61-B as seen in the cutaway view of figure 350 are the azimuth base assembly, the elevation yoke assembly, the spinner assembly, and the antenna and reflector. These parts house the components that turn the antenna in azimuth and elevation, spin the dipole of the antenna, and furnish information as to the direction in which the antenna is pointing.

317. AZIMUTH BASE ASSEMBLY.

The azimuth base assembly is the lower stationary part of the antenna mount. It supports the elevation base and houses the following components:

a. Azimuth Drive Motor. The azimuth drive motor is mounted under the housing around the azimuth base. The drive motor provides the motive power for rotating the antenna in azimuth. A planetary gear train reduces the speed of the drive motor to the maximum running speed of 6.4 rpm. An oil pump circulates oil through the reduction gearing and bearings.

b. Azimuth Selsyns and Potentiometer. The four azimuth selsyns and the azimuth potentiometer are driven by the selsyn drive gears. The PPI selsyn, coarse azimuth selsyn, azimuth selsyn transformers, and the azimuth potentiometer are driven at the same speed as the antenna mount. The fine azimuth selsyn is driven 16 times the speed of the antenna mount. The fine azimuth selsyn and the azimuth selsyn transformer are coupled to the drive shaft through anti-backlash gearing.

c. Azimuth Drive Shaft Assembly. The azimuth drive shaft assembly is contained in the pedestal housing. It includes the shaft that turns the elevation yoke, its bearings and oil seals, and the slip rings and brushes that transmit voltages between the stationary and rotating parts of the antenna mount.

318. ELEVATION YOKE ASSEMBLY.

The elevation yoke is the part of the mount that holds the reflector support and tilts the reflector in elevation. The elevation yoke is driven in azimuth by the azimuth drive shaft. The following components are housed in the elevation yoke:

a. Elevation Drive Motor. The elevation drive motor is mounted on the elevation drive case. The planetary reduction gear train and idler gears are housed inside the elevation drive case. An oil pump within the drive case circulates oil over the reduction gears and bearings.

b. Elevation Potentiometer and Selsyns. The three elevation selsyns are mounted inside the elevation yoke. The elevation potentiometer is mounted on the outside of the yoke opposite the elevation drive case. The coarse elevation selsyn, selsyn transformer, and elevation potentiometer are driven through the same angle as the reflector. The fine elevation selsyn is driven through an angle 16 times as large. The elevation potentiometer is coupled to the elevation axis through anti-backlash gears.

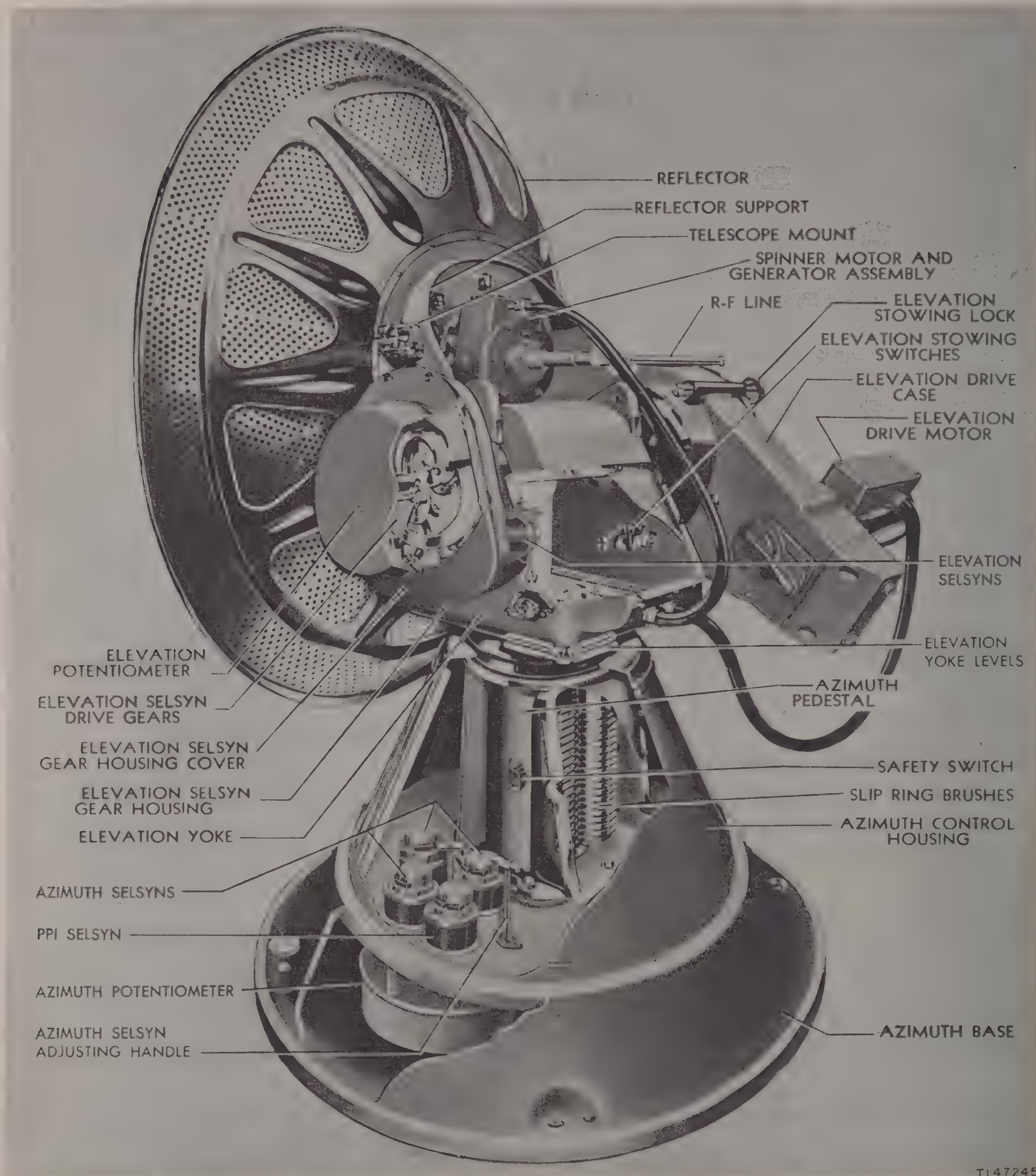


Figure 350. Antenna mount MP-61-B, cutaway view.

319. SPINNER ASSEMBLY.

The spinner assembly is mounted on the elevation yoke behind the reflector. The following components make up the spinner assembly:

a. Reference Generator. The reference generator is an alternating current generator driven by the spinner motor at the same rate as the dipole. Two 30-cycle output voltages are taken from the reference generator. These reference voltages are 90 degrees out-of-phase, corresponding to an azimuth reference voltage and an elevation reference voltage.

b. Spinner Motor. The spinner motor is a three-phase induction motor that spins the dipole assembly and reference generator at 1,800 rpm. The motor and generator armature are mounted on the same hollow shaft. The r-f line passes through the shaft. A high-speed airtight rotary joint is located inside the hollow motor generator shaft. The antenna is fastened to the end of the shaft.

320. DIPOLE ASSEMBLY AND REFLECTOR.

The reflector and reflector supports are mounted on the elevation yoke. The reflector is a paraboloidal stamped steel dish. The diameter of the reflector at the opening is 6 feet. The dipole is covered with a plastic shell and is mounted at the focal point of the paraboloid. The functioning of the dipole and reflector is covered in chapter 3.

SECTION II
SERVICING THE MOUNT

321. TOOL KITS.

The tools for Antenna Mount MP-61-B which are supplied with the equipment are shown in figure 351 and are listed in the table under the heading of equipment antenna mount tools. Depot tools consist of the equipment tools with the addition of the tools listed in the table under the heading of depot antenna mount tools. These supplementary tools are shown in figure 352. The numbers in the left-hand column of the tables IV and V refer to the numbers on the illustrations. Tools identified with a letter and a number are marked with the same letters and numbers shown in the pictures.

322. GENERAL INSTRUCTIONS FOR DISASSEMBLY AND ASSEMBLY OF THE MOUNT.

In the following sections that deal with removing and replacing the antenna mount parts, the instructions on removal and disassembly of parts are, in most cases, very complete. Exploded views, showing the parts of the major assemblies in the order they are taken apart, are included with the text. Other figures show the relation of the parts when they are assembled. The technician should study the instructions and the illustrations very carefully in order to become thoroughly familiar with the procedure required. Replacement instructions are not given unless special problems are involved. The general precautionary instructions given below are to be followed whenever they apply to the work being done.

a. The seven rules listed below apply to all the parts:

(*1*) Always keep the parts clean.

(*2*) Sort them in orderly fashion where they will not be knocked over or lost.

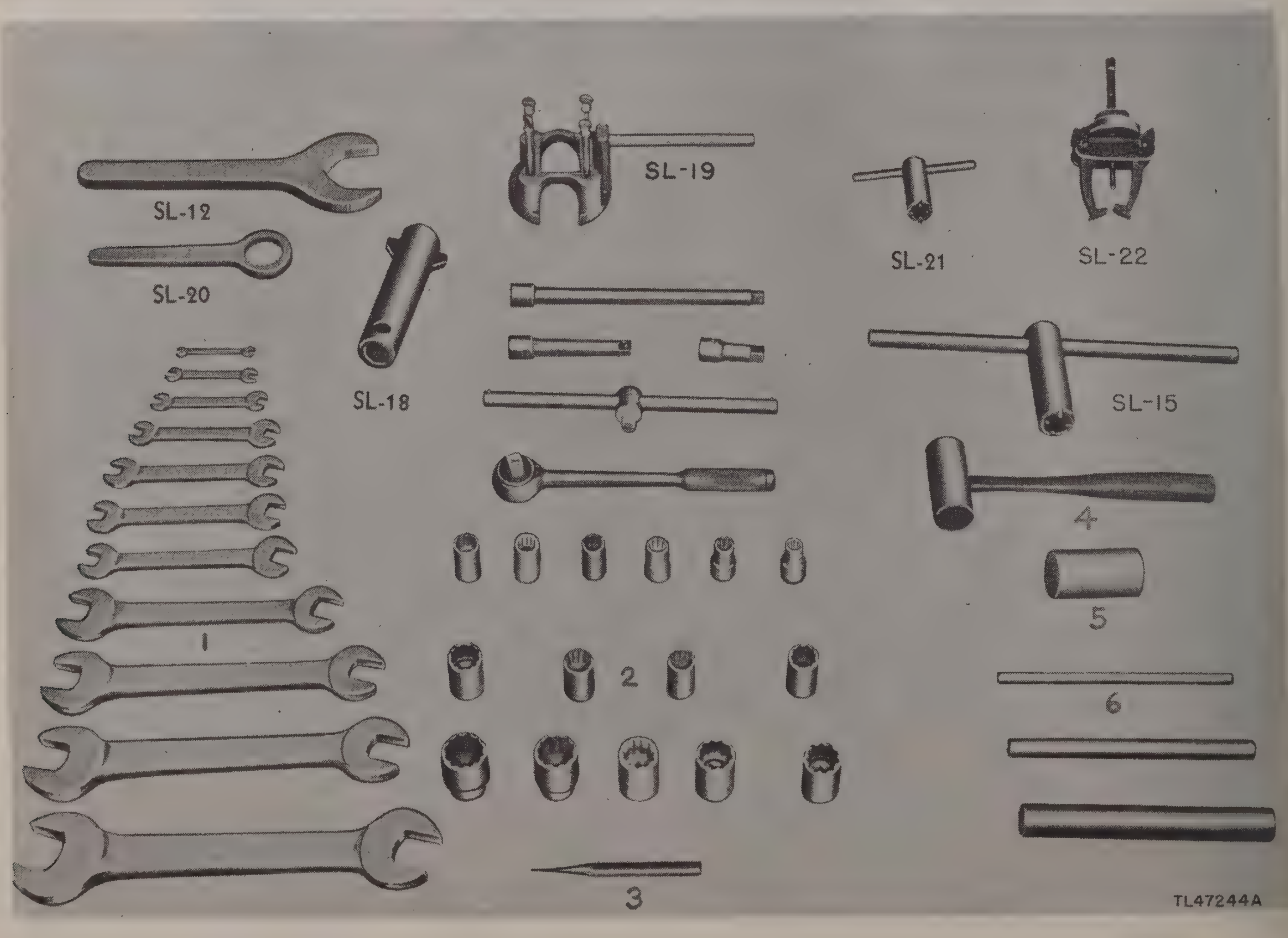


Figure 351. Equipment antenna mount tools.

(3) Observe carefully any specific precautions that are given.

(4) Always clean and lubricate metal parts before reassembly.

(5) Never use more force than is necessary to remove or install parts.

(6) Always replace damaged gaskets with new ones.

(7) Use the proper tool for the job.

> **NOTE:** The tools supplied with the pedestal are designated by SL numbers: SL-1, SL-2, SL-3, etc., with the exception of the tool for removing the snap rings, which carries number C-484. These numbers are used throughout the text.

b. Never hammer a part with material harder than itself; once a part is changed in shape, it is likely to be good for nothing but scrap. Use brass tapping bars on steel parts which must be driven into or pulled out of tight fits. Use a soft mallet where the bars do not apply. Do not hit too hard. Many of the parts in the pedestal are close fits; some have been press-fitted into other parts. These are difficult to disassemble unless adequate shop equipment is available. Pullers are necessary for removing the gears from the shafts. Major disassembly operations involving large parts pressed together should never be attempted in the field except in cases of dire necessity. Tapping press-fitted parts into or out of assembly with bar and hammer is, at best, a difficult and tedious operation. In some cases requiring very infrequent disassembly, no other method is available. Always tap evenly all the way around the part. Tapping too much in one place may result in cocking the tapped part and making it stick tighter or even gall in the other part. On starting a press-fitted part into a hole, be certain that it starts straight. Plenty of oil should always be used when making a press fitting. Screws must be tightened sufficiently to prevent loosening but not enough to strip the threads; the smaller the screw, the less the turning effort required to strip it.

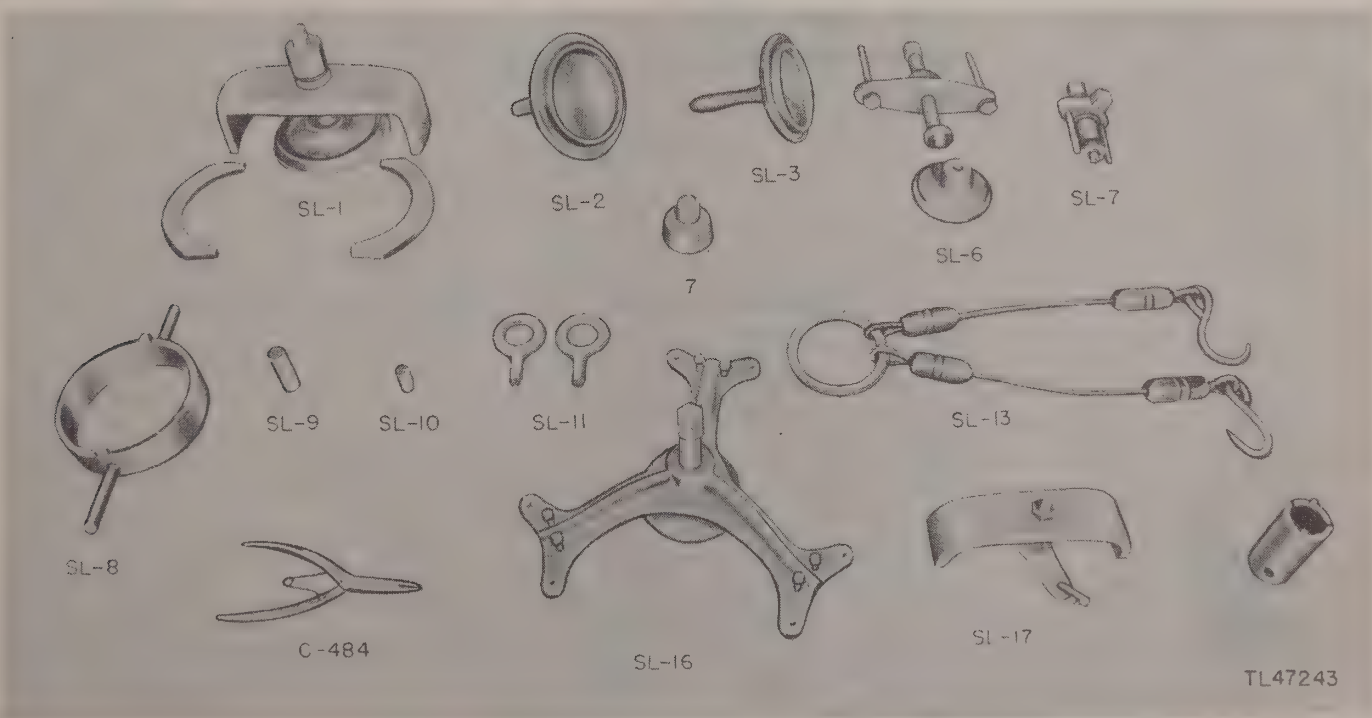


Figure 352. Depot antenna mount tools.

TABLE IV

EQUIPMENT ANTENNA MOUNT TOOLS

Number	Description
SL-12	Open-end wrench for elevation adjusting arm nut.
SL-15	Socket wrench for high-speed r-f joint seal nut.
SL-18	Wrench for high-speed r-f joint seal.
SL-19	Wrench assembly for spinner motor drive flange.
SL-20	Wrench to hold elevation potentiometer gear.
SL-21	Wrench for elevation potentiometer gear.
SL-22	Drive motor coupling puller.
1	Open-end wrench set, 7/32″ to 1 3/8″.
2	Socket wrench set, 7/16″ to 1 1/8″.
3	Punch.
4	Mallet.
5	Hardwood block.
6	Brass bars, 3/8″ diam, 5/8″ diam, and 1″ diam.

TABLE V

DEPOT ANTENNA MOUNT TOOLS

Number	Description
SL-1	Puller for main azimuth bearing cups.
SL-2	Driver for assembling seal into oil reservoir and cover assembly.
SL-3	Driver for assembly elevation oil seal into drive case cover.
SL-6	Puller for elevation main drive gear.
SL-7	Puller for output annulus drive pinion gear.
SL-8	Wrench for azimuth drive shaft bearing nut.
SL-9	Dummy shaft for elevation idler pinion assembly.
SL-10	Dummy shaft for planet pinion assembly.
SL-11	Eyebolts for pulling azimuth drive shaft.
SL-13	Lifting cable to lift complete mount.
SL-14	Wrench for high-speed r-f rotating joint seal.
SL-16	Puller for removing elevation drive case.
SL-17	Puller for stationary annulus.
C-484	Snap-ring pliers.
7	Driver for output annulus bearings.

CHAPTER 22
AZIMUTH BASE ASSEMBLY

SECTION I
DESCRIPTION

323. AZIMUTH DRIVE TRAIN.

a. Location. The azimuth drive train includes the drive motor, the planetary gear assembly, the drive gears, and the oil pump. A cutaway view is shown in figure 353.

b. Azimuth Drive Motor. The azimuth drive motor is a ½-horsepower, 250-volt direct current reversible motor. The rated speed of this motor is 3,600 rpm. When the motor runs at this speed, it turns the antenna mount at 6.4 rpm. Instructions on dismantling this motor for service of the bearings are given in TM 11-1454.

c. Oldham Coupling. The Oldham coupling allows for a slight misalignment between the motor shaft and the reduction gears. This coupling consists of a coupling member, a coupling block and the hub of the sun gear (fig. 353). This coupling member is keyed and locked with a setscrew to the motor drive shaft. Slots in the coupling member and the hub of the sun gear fit into tongues in the coupling block. The tongues are angularly spaced to each other at 90 degrees so that the end members (the coupling and the hub of the sun gear) may be offset in any direction as long as their axes remain parallel.

d. Planetary Reduction Gears. The planetary reduction gears make it possible to obtain great reduction of speed in a small space with a minimum of gearing. The equipment for the planetary reduction gears consists of a sun gear, three compound planet pinions, a planet pinion carrier, a stationary annulus (ring gear) and an output annulus (fig. 353). The sun gear is driven by the motor through the Oldham coupling. This 17-tooth gear meshes with the top 19-tooth gear in each of the three compound planetary pinions. These planetary pinions mesh with the 55-tooth stationary annulus, which is clamped firmly between the motor frame and the azimuth base. The bottom 18-tooth gear of each of the three compound planetary pinions meshes with the 54-tooth output annulus. When the sun gear turns at 3,600 rpm, the planet gear carrier revolves at 849 [3,600 ÷ (55/19 x 19/17 + 1)] rpm inside the fixed annulus. This causes the planetary gears to turn on their own axes at a speed of 2,457 (849 x 55/19) rpm. Since the rotation of the planet pinions causes the output annulus to turn at 819 (2,457 x 18/54) rpm, while the planet carrier pulls the output annulus around in the opposite direction at a rate of 849 rpm, the output annulus, as a result turns at a rate equal to the difference of the two speeds, or at 30 (849-819) rpm. This speed is further reduced by the 19-tooth drive pinion which meshes with the 89-tooth drive gear to 6.4 (30 x 19/89) rpm.

e. Azimuth Oil Pump. The planetary gears, bearings, drive pinion, and main drive gear are all lubricated by oil circulated from the azimuth oil pump, contained within the pump housing (fig. 353). The pump is operated by a cam that is fastened with a dowel pin to the lower end of the output annulus hub. The face of the cam is cut at a 75-degree angle to its axis of rotation. As the cam turns, it alternately pushes and releases the pump plunger which is held against it by a spring. When the plunger moves up, it uncovers a hole in the pump housing through which oil from the reservoir is drawn into the cavity below the plunger. When the plunger is pushed downward by the cam, it first covers the hole in the housing and then continues to descend, forcing the oil trapped beneath it to push open the ball check valve and move up the tube through the center of the planetary gear system. The tube soon fills and overflows as successive shots of oil are delivered by the pump. The oil

flows out through the Oldham coupling and spreads over the sun gear, running down into the sun and planet teeth and being carried out to the teeth of the stationary annulus. Oil running down from the stationary annulus and upper planets lubricates the teeth of the lower planets and the output annulus. It also flows through holes in the output annulus to pass over the ball bearings and reach the teeth of the azimuth drive pinion and be carried around the main drive gear. Holes in the supporting case formed by the recess in the azimuth base permit oil to flow down onto the top surface of the main drive gear, and some of this may be thrown over far enough to reach the selysn input gear. However, positive lubrication of the selsyn drive gears is not necessary at the low speeds and light loads under which they operate. Oil dropping

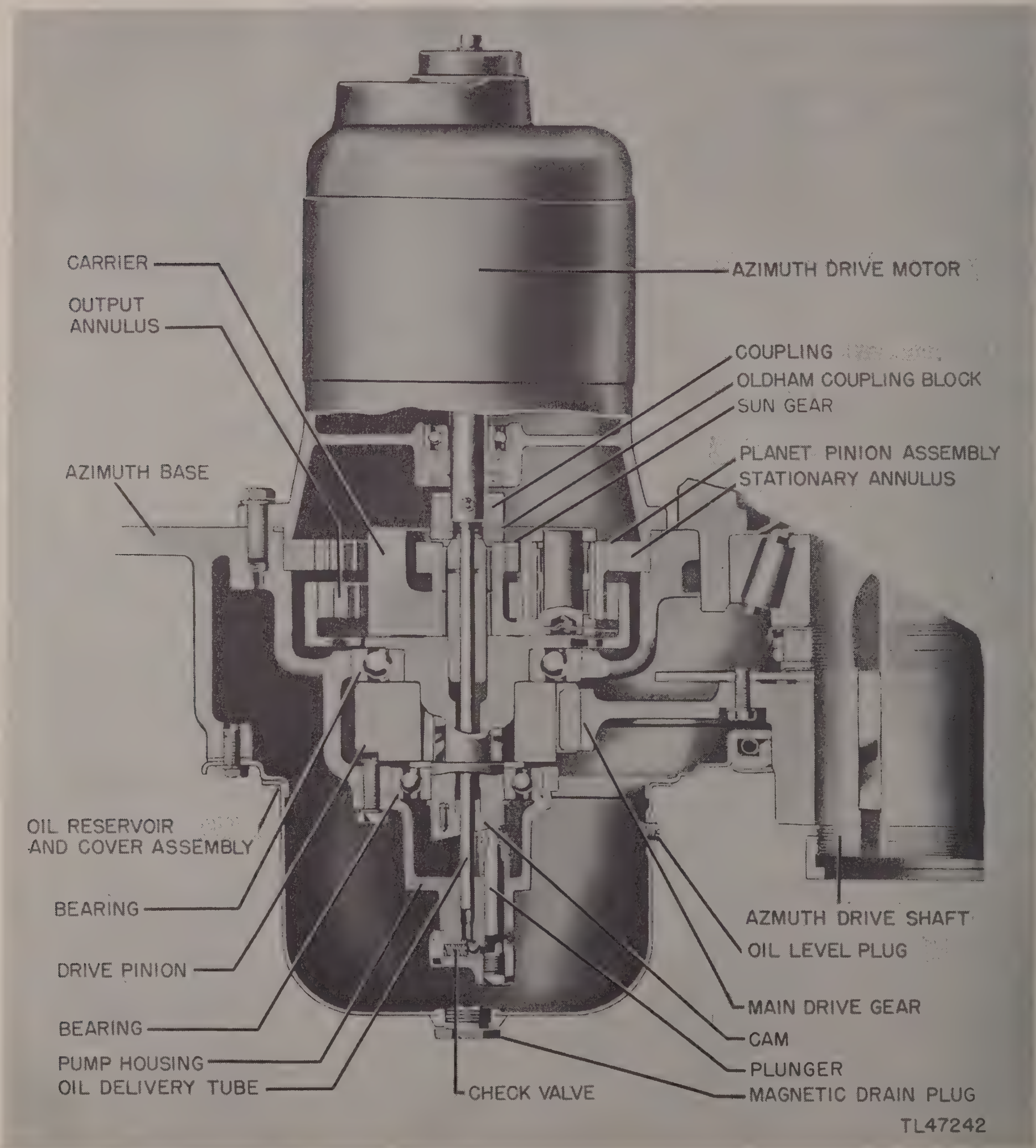


Figure 353. Azimuth drive train, cutaway view.

from the drive pinion falls on the lower ball bearing through which it can reach the interior of the oil housing. The housing eventually runs full, providing an oil bath for the cam and plunger. The excess then overflows from the bearing into the oil reservoir.

324. AZIMUTH SELSYNS AND POTENTIOMETER DRIVE TRAIN.

a. Location. The azimuth selsyns and potentiometer drive train includes the gears, clutch, selsyns, and potentiometer. A cutaway view is shown in figure 354.

b. Selsyn Drive Shaft. The 260-tooth selsyn input gear mounted on the antenna azimuth drive shaft drives a 260-tooth gear that is free to rotate on the selsyn drive shaft. A clutch couples the driven gear to the gears on the selsyn drive shaft. When the clutch is in the operating position, these gears turn the selsyn drive shaft at the same speed as the azimuth drive shaft.

c. Selsyn Orienting and Locking Clutch. The clutch that couples the driven gear to the drive shaft makes it possible to turn the selsyns and the potentiometer for purposes of orientation without changing the position of the antenna. Figure 356 shows the operation of the clutch and orienting pinion. Operation of the clutch is as follows:

(*1*) Depressing the orienting handle meshes the orienting pinion with the 272-tooth selsyn drive gear.

(*2*) Holding the orienting handle in place and turning the locking handle counterclockwise causes the 72-tooth and the 272-tooth selsyn drive gears to rise from the clutch disk which lies between the 272-tooth and the 260-tooth gears on the selsyn drive shaft (fig. 356). The two selsyn drive gears are keyed to the shaft and are also fastened to a threaded sleeve. A hollow plug fits inside the threaded sleeve and is bolted to the locking handle. When the locking handle is turned clockwise, the sleeve is pulled up by the plug. Since the selsyn drive gears are bolted to the sleeve and are only keyed to the selsyn drive shaft, they also rise with the sleeve. This removes any friction that may exist between the driven gear and the larger selsyn drive gear through the clutch disk.

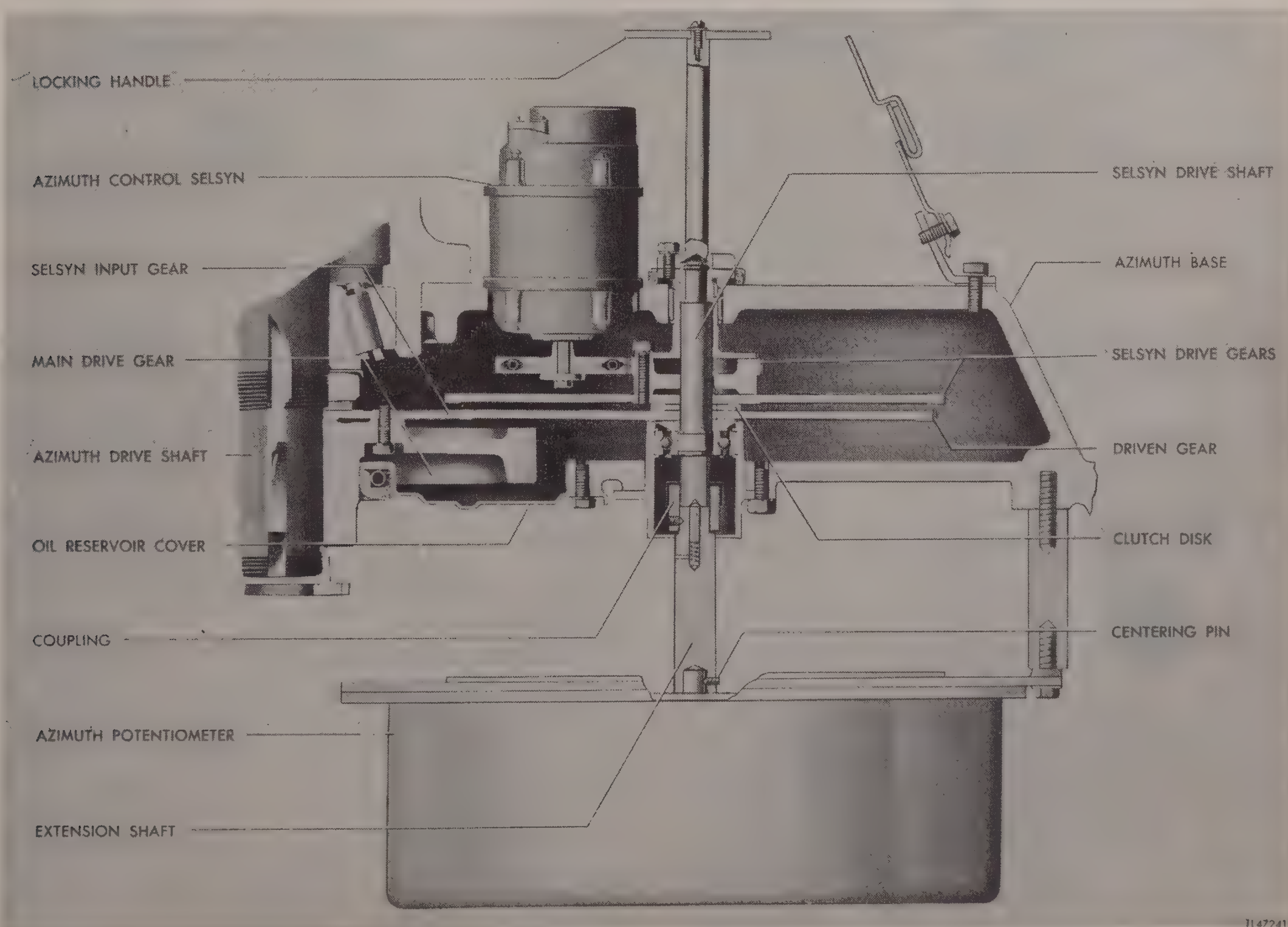


Figure 354. Azimuth selsyn drive train, cutaway view.

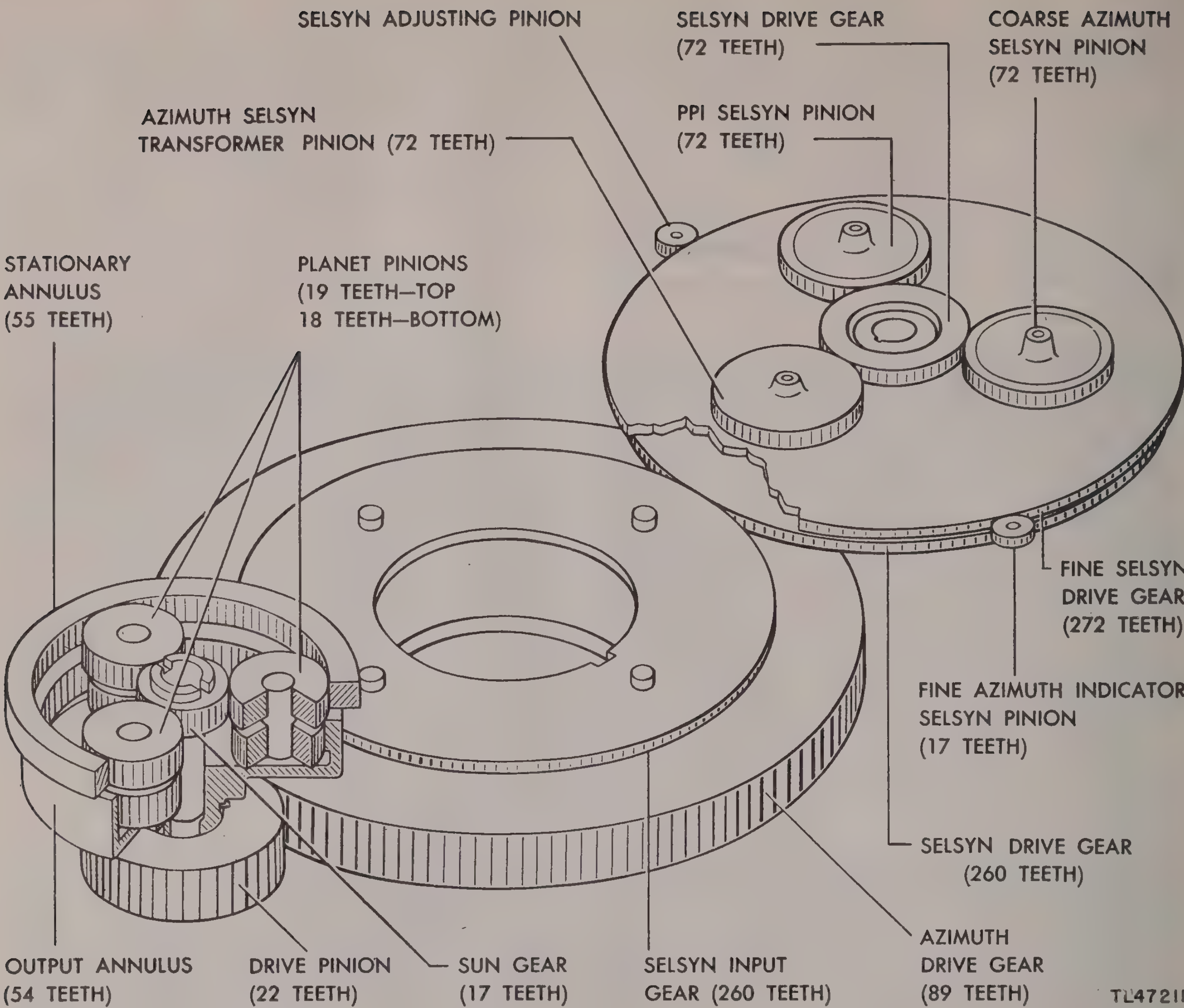


Figure 355. Azimuth drive train, plan view.

(*3*) Turning the orienting handle turns the selsyn drive shaft, moving the selsyns and the potentiometer without turning the azimuth drive shaft.

(*4*) Turning the locking handle clockwise compresses the gears against the clutch plate and restores the driving friction between the driven gear and the drive gears. It is necessary to depress the orienting handle and hold it in place to prevent the selsyn drive shaft from turning.

d. Selsyn and Potentiometer Drives. The three 1 to 1 ration selsyns (the PPI coarse azimuth, and the selsyn transformer) each has 72-tooth gears on their shafts. These gears mesh with the 72-tooth drive gear on the selsyn drive shaft; so the three selsyn armatures make one turn for each turn of the selsyn drive shaft which turns once for each turn of the azimuth drive shaft. The 16 to 1 fine azimuth selsyn carries a 17-tooth pinion that meshes with the 272-tooth gear on the selsyn drive shaft; so the armature of this selsyn makes 16 turns to each turn of the selsyn drive shaft and the azimuth drive shaft. The azimuth potentiometer is coupled to the end of the selsyn drive shaft and thus makes one turn for each turn of the azimuth drive shaft.

e. Anti-backlash Coupling. The azimuth selsyn drive shaft is coupled to the potentiometer shaft by an anti-backlash coupling (fig. 354). A tongue on the drive shaft projects into a slot in the coupling member on the potentiometer shaft. Spring-loaded balls project from the two sides of the tongue on opposite sides of the shaft axis. When the tongue is inserted into the slot on the coupling member, the spring-loaded balls and brass shims take up any clearance that may exist

between the tongue and the slot. The two shafts are kept in alignment by a centering pin in the potentiometer shaft extension. This arrangement eliminates any play between the potentiometer and the selsyn drive shaft.

f. Anti-backlash Gear. The fine azimuth selsyn and azimuth selsyn transformer are coupled to the selsyn drive shaft through anti-backlash gear arrangements. A slight amount of clearance is always provided between the teeth of any two meshing gears to prevent them from binding. This means that if one gear is held in place, the other gear can be rattled back and forth through this small clearance distance. When the direction of rotation of the two gears reverses during operation, this same effect occurs. To remove this backlash play, one of the meshing gears is replaced by a pair of gears located side by side. One gear is fastened to the shaft, and the other gear is free to turn on the shaft. A compressed spring is placed between these gears. The action of the spring tends to make one gear progress ahead of the other gear. The resulting displacement is sufficient to take up any play between these gears and the gear with which they mesh.

325. AZIMUTH DRIVE SHAFT.

The azimuth drive shaft (fig. 357) is a steel tube with a 5⅛-inch outside diameter and a 3⅞-inch inside diameter. The lower end of the shaft is threaded to hold the main bearing locknut. Below the main bearing locknut, the shaft is slotted for the keys that prevent any slippage between the shaft and the drive gear. This drive gear is held in place on the shaft between the main bearing locknut and a snap ring. The extreme end of the drive shaft is threaded to hold the nut which in turn holds the r-f line that comes up through the center of the azimuth drive shaft. A flange is welded to the top of the drive shaft. Holes are drilled in the top of the flange to allow the slip-ring leads to extend up to the terminal block on the bottom of the elevation base assembly. The upper and the lower azimuth bearings are cone-shaped and are mounted with the points of their cones pointing toward each other. The upper bearing is mounted on the flange section of the drive shaft, and the lower bearing is mounted on the shaft just above the threaded portion for the locknut. The locknut under the lower bearing is held in place by a cupped lockwasher which has a tongue on its inside rim that fits into the slot on the drive shaft. During assembly, the locknut is brought against the lower bearing and tightened so that there is a 1,200-pound push between the two cone-shaped bearings. When the locknut is tightened, the cupped washer is bent against the locknut to prevent the nut from turning on the shaft. The 1,200-pound push between the bearings pulls the shaft firmly into position and prevents any wobbling of the antenna as it is rotated.

326. SLIP-RING ASSEMBLY.

The slip rings and brushes transfer voltages between the stationary and rotating parts of the antenna mount. The slip rings are made of bronze with a coating of silver on the outside. Each ring has a bronze pin soldered to the inner surface. There is a slot in the end of the pin to take the wire leading from the ring to the terminal strip in the elevation selsyn compartment. There are 43 of these slip rings and five dummy rings that are made of galvanized steel wire. A slip-ring spacer separates the rings from the flange at the top of the shaft, and the individual rings are separated from each other by insulators (fig. 358). These insulators have internal teeth

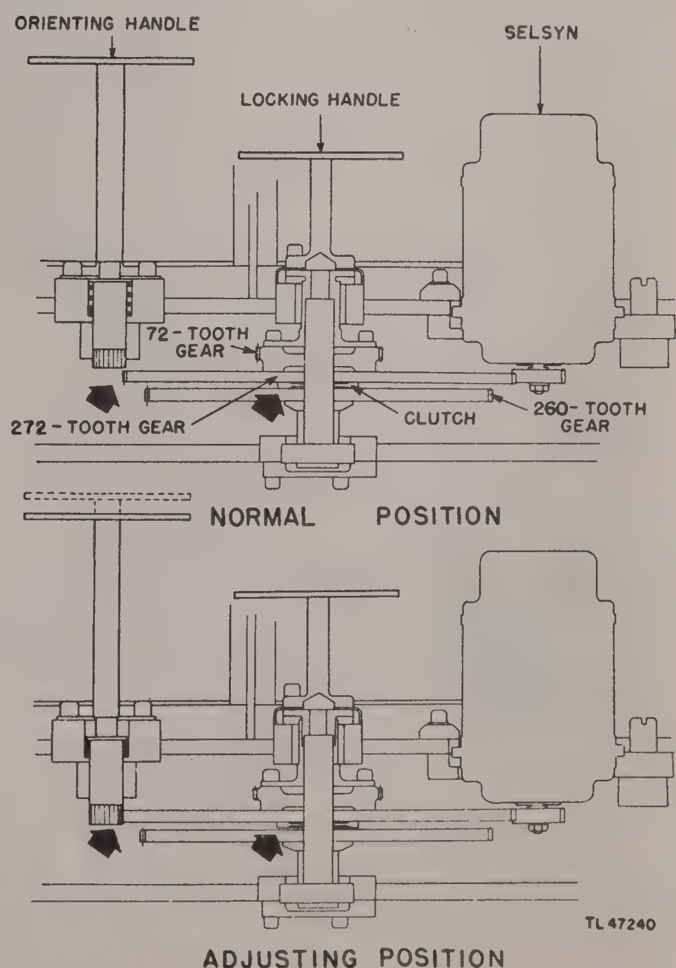


Figure 356. Selsyn orienting and locking detail.

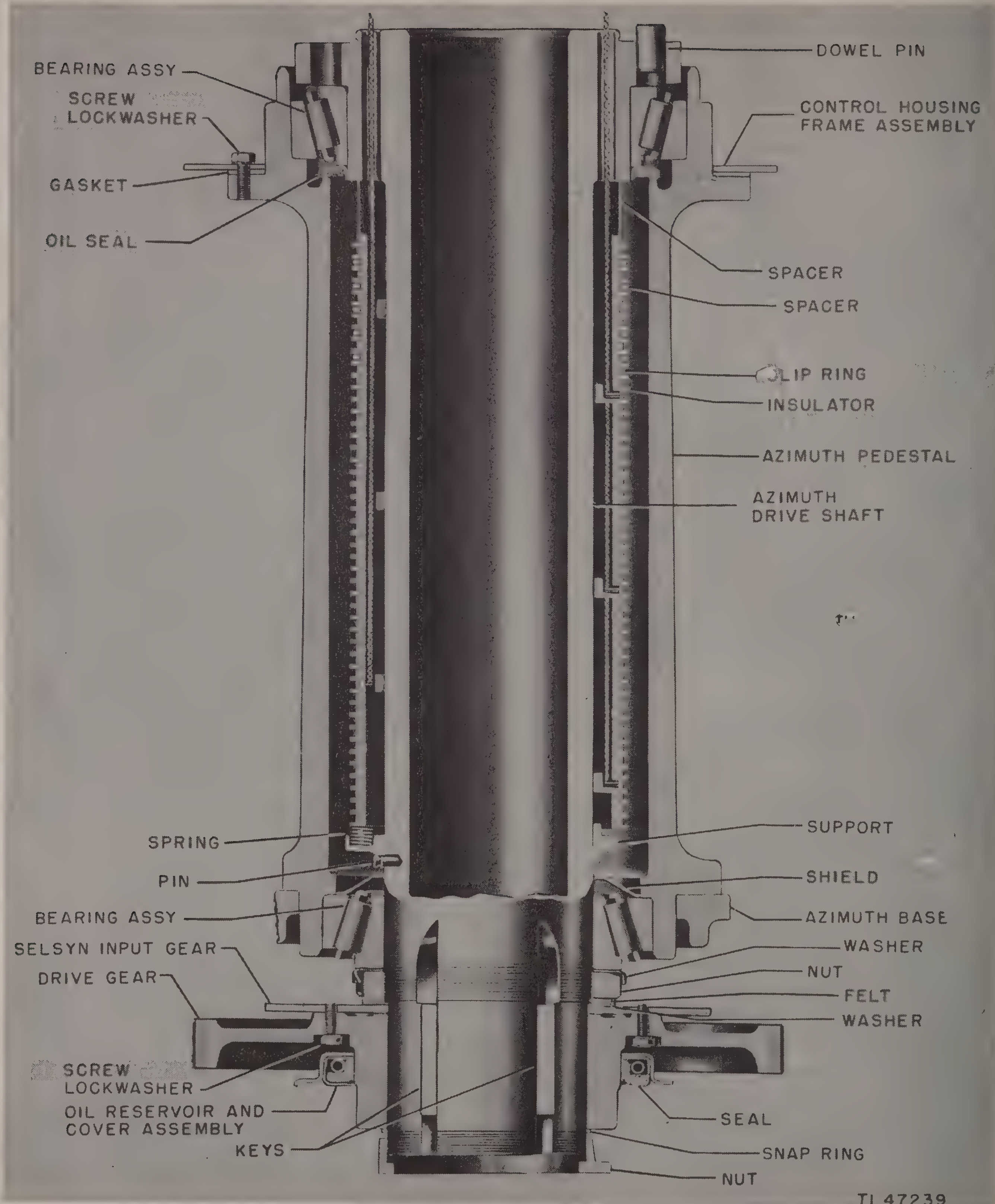


Figure 357. Azimuth drive shaft.

which hold the rings in place about the shaft and allow space for the passage of the leads from the rings to the selsyn compartment. The whole slip-ring assembly is held in place by the slip-ring support. Four pins hold the support to the drive shaft. Four coil springs fit into pockets in the clamp and press the whole assembly together. The slip rings extend 1/32 inch above the top of the insulators; so the clamping action of the springs is transmitted from one insulator to the next by the rings. The friction between the rings and the insulators keeps the assembly from turning. As an added precaution, the rings are keyed together. The brushes that ride on the slip rings are blocks of silver graphite that are soldered to a strip of phosphor bronze called the contact arm (fig. 359). Positive contact is insured by another strip of phosphor bronze which is bent to form a spring and bear against the arm from behind with a force of from 1 to 2 pounds. The brushes are spaced on two terminal boards to index with every other slip ring. The brushes attached to TB1 contact the odd numbered rings while those attached to TB2 contact the even numbered rings.

327. AZIMUTH STOWING LOCK.

The azimuth stowing switch S2002 and the azimuth stowing lock are mounted on a bracket attached to the azimuth base near the elevation yoke (fig. 360). The switch is mounted inside the azimuth base control housing and the lock

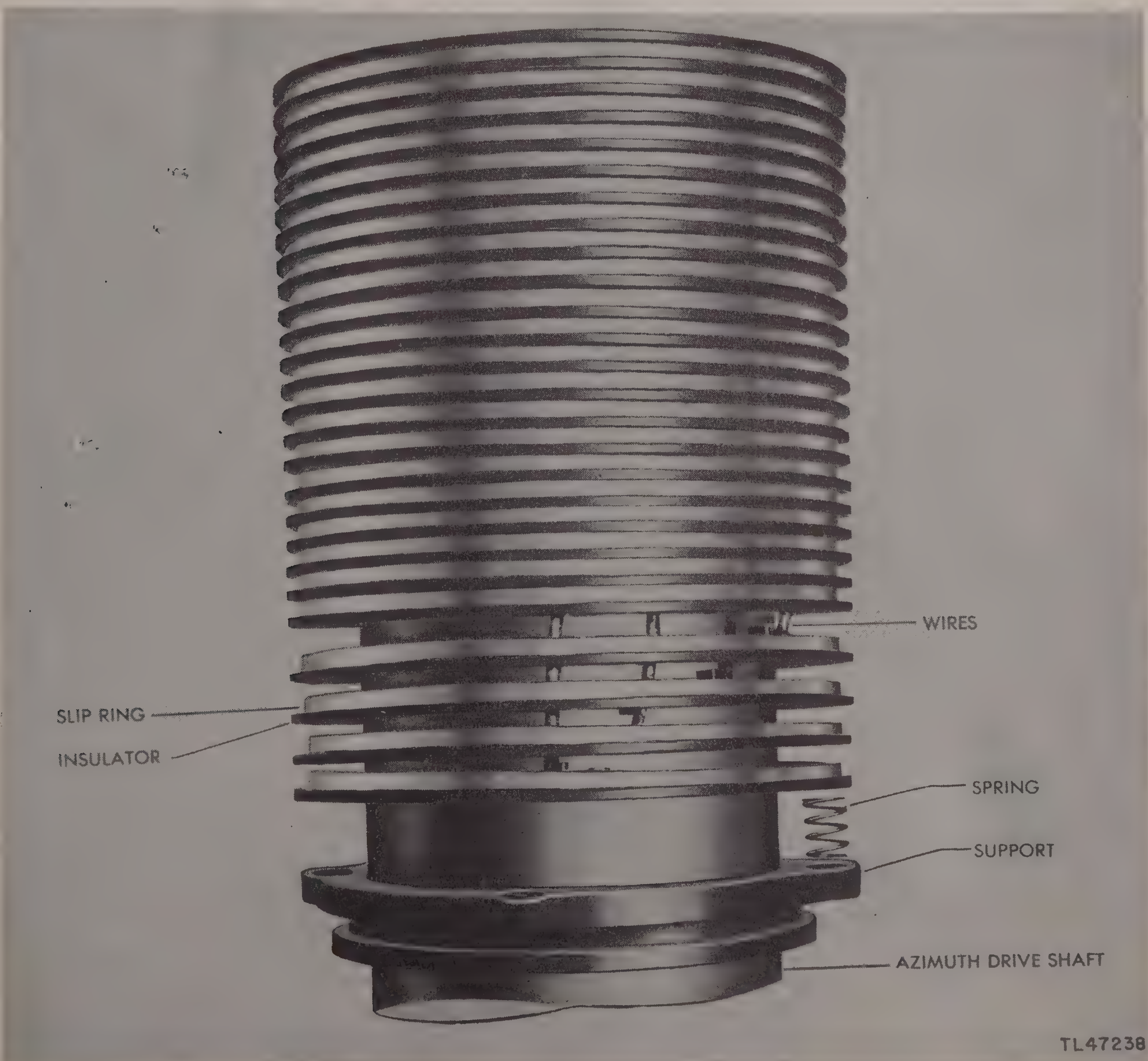


Figure 358. Slip rings and insulators.

outside. When the lock handle is turned counterclockwise, the nut unscrews from the bracket, pulling the shaft with it. The shaft pulls the lock away from the piece of brake lining attached to the flange of the elevation yoke, just in front of the lock. The handle reaches a stop when the lock strikes the face of the bracket. When the handle is turned clockwise, the nut moves into the threads in the bracket, and by direct contact with the rear surface of the lock, forces it in against the brake lining. This prevents the elevation yoke and its attached parts from being turned in azimuth.

328. AZIMUTH STOWING SWITCH.

The azimuth stowing switch S2002 (fig. 360) prevents the operation of the azimuth drive motor B2001 when the reflector is locked in its traveling position. The switch is mounted horizontally in a stamped bracket. A screw passes through a hole at one end of the switch body and serves as a pivot. The switch is supported at the other end by a spring-loaded adjusting screw. Screwing the adjusting screw into the bracket raises the end of the switch on which the pin is located. Thus it can be adjusted to trip within the travel of the plunger. This plunger indexes with the groove at the rear of the lock when the lock is fully disengaged. In this position, the plunger is pushed into the groove by the spring which surrounds the switch pin and pushes upward on the plunger. As the lock moves into engagement with the brake shoe, the plunger is forced downward by movement of the groove out of index. This depresses the switch pin and opens the switch S2002, preventing operation of the azimuth drive motor B2001.

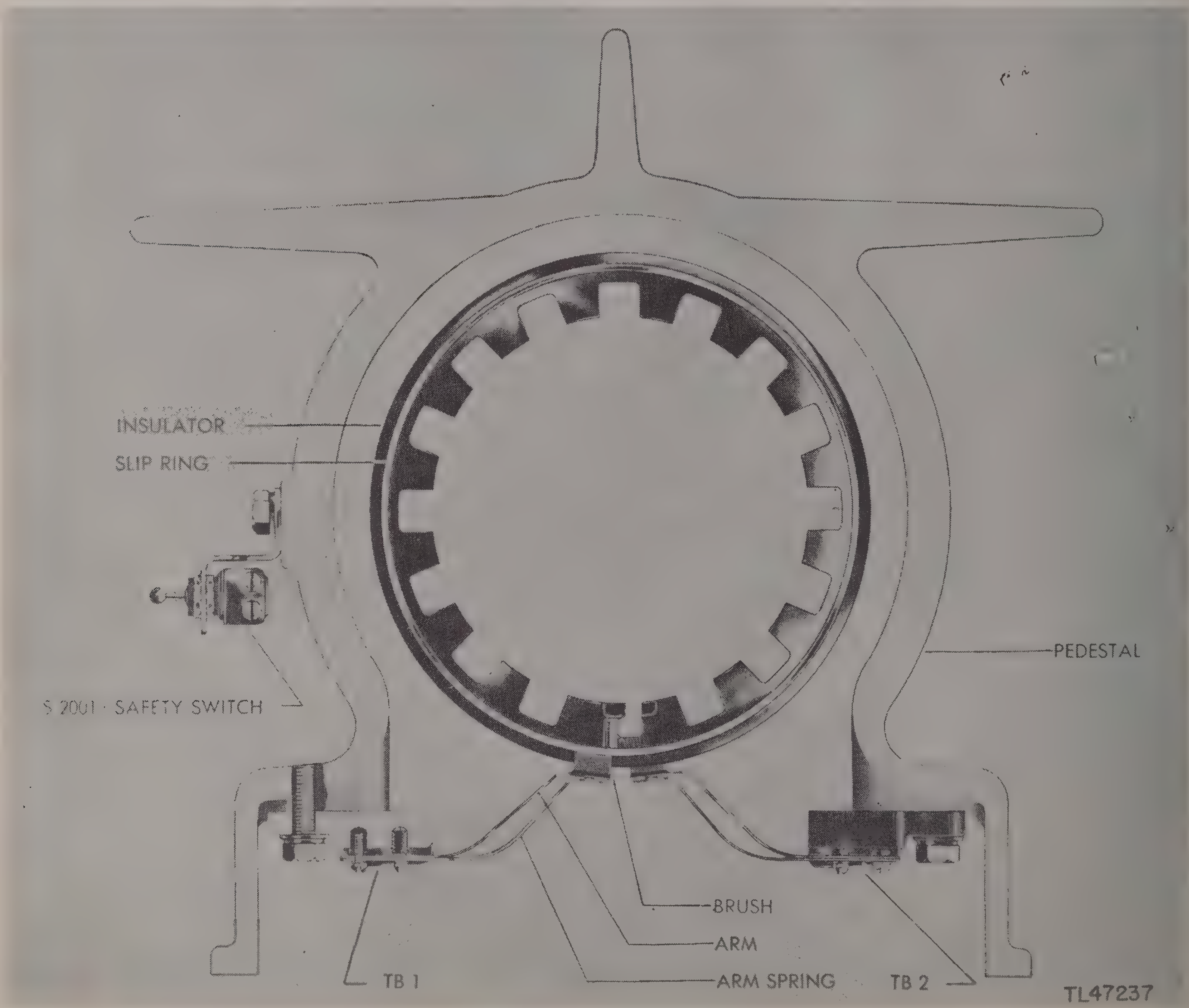


Figure 359. Slip ring and brush.

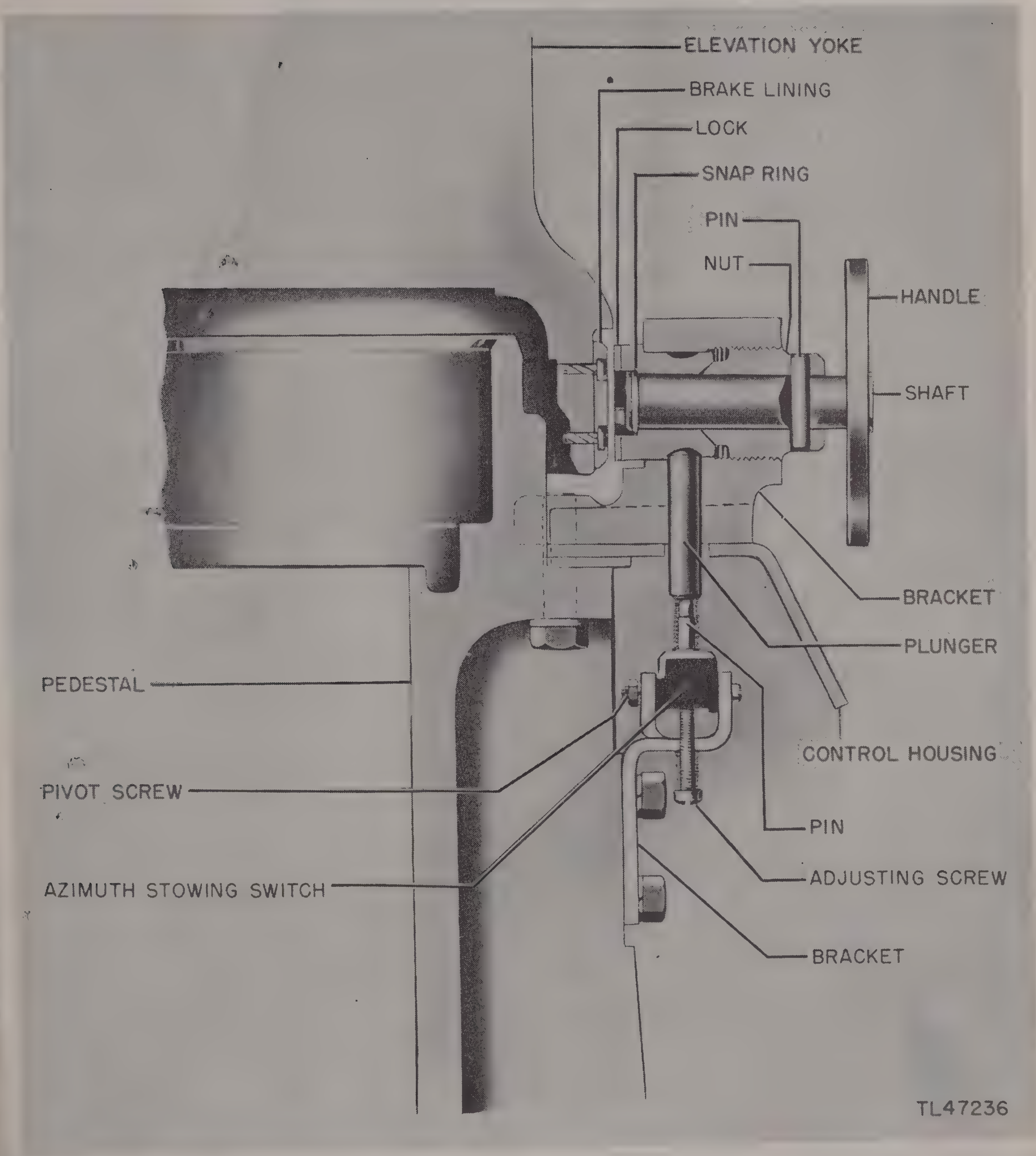


Figure 360. Azimuth stowing lock and switch.

SECTION II
DISASSEMBLY

329. OIL RESERVOIR.

To remove the oil reservoir and cover assembly (fig. 361) located underneath the mount, the following steps must be taken:

a. Remove the azimuth potentiometer by:

(*1*) Disconnecting the leads.

(*2*) Removing the three screws supporting the potentiometer. The potentiometer weighs 48.5 pounds; so it is necessary to have one man support it while another removes the screws.

b. Remove the section of r-f transmission line that extends up through the azimuth drive shaft. Proceed as follows:

(*1*) Remove the cover on the elevation selsyn compartment.

(*2*) Inside at the bottom of the compartment, remove both halves of the "spider" that holds the r-f transmission line in the upright position. The joint in the line is now visible. Unfasten the connector so that the lower section of line can later be pulled out from below.

(*3*) Now, in the trailer, remove the section of transmission line that extends across the trailer, from the azimuth base. Be extremely careful to avoid damaging the joints.

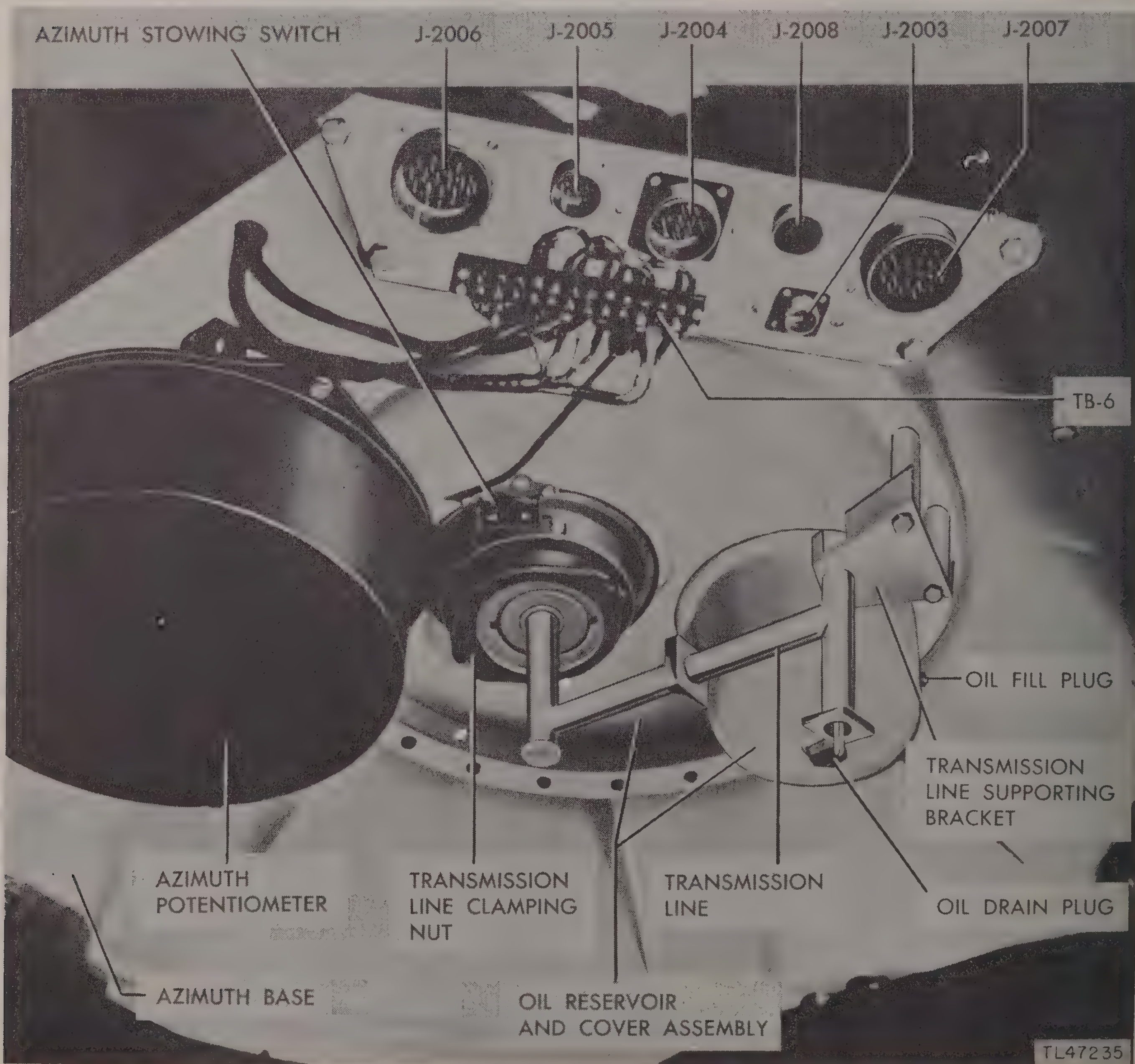


Figure 361. Antenna mount, bottom view.

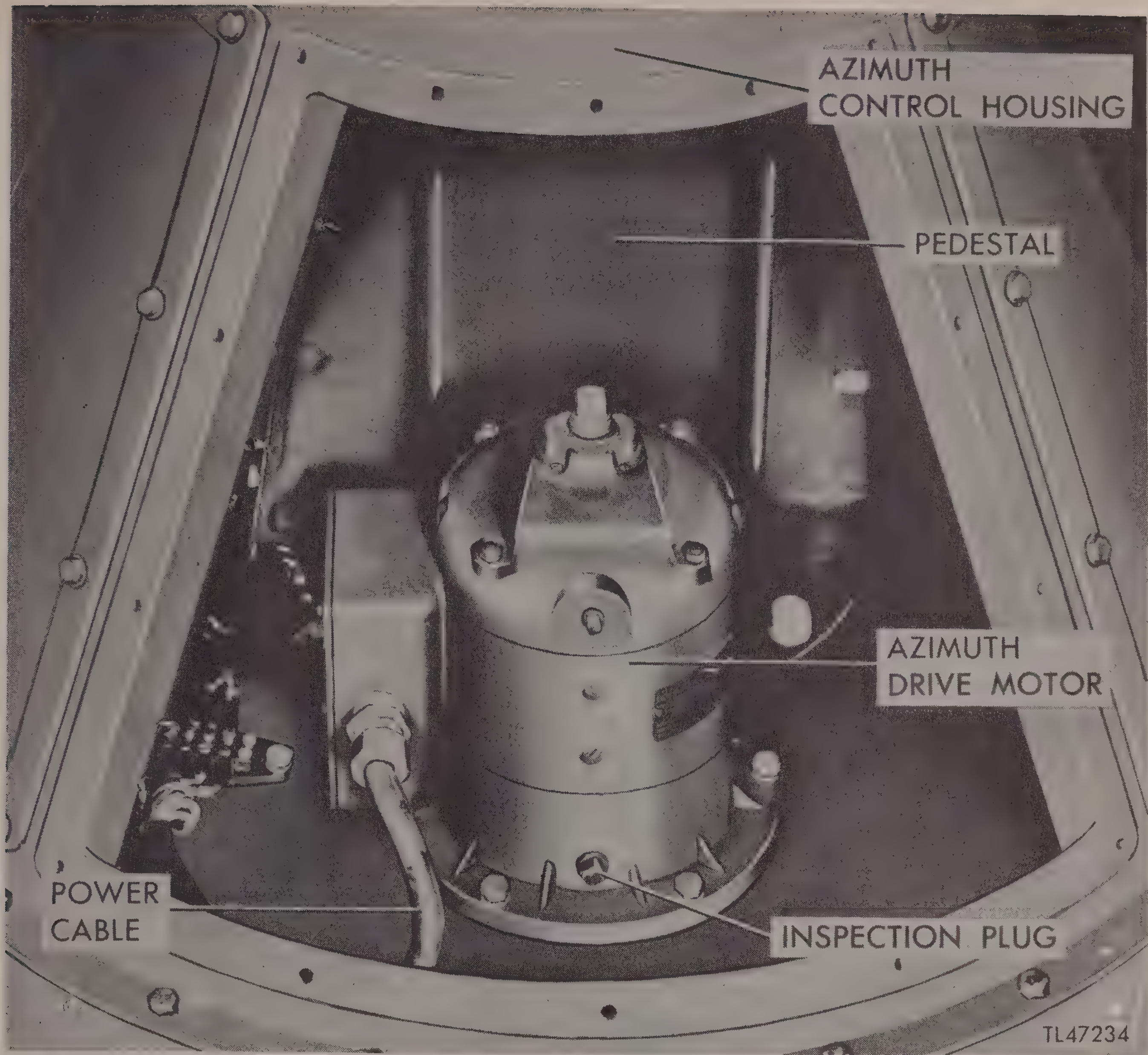


Figure 362. Azimuth drive motor.

(*4*) Remove the transmission line clamping nut after tapping it loose with a hammer and brass bar.

(*5*) Press the r-f line sideways carefully just far enough to free it from the supporting bracket on the oil reservoir and cover assembly. Bend the bracket slightly if necessary.

(*6*) Lower the section of r-f line out of the drive shaft carefully. Remove the clamping nut from it.

c. Drain the oil from the oil reservoir, and replace the plug.

d. Disconnect the wires on the azimuth stowing switch S2003.

e. Remove the cover screws. One person should support the cover assembly while another removes the screws.

f. Lower the cover carefully until it is clear, and then set it aside. An effort should be made not to damage the gasket.

g. Wipe away any oil that might drip on the trailer floor.

330. AZIMUTH DRIVE MOTOR.

Since the power cable to the drive motor (fig. 362) is long enough to allow the motor to be removed and set on its side near the mount, the cable does not have to be disconnected unless the motor is being removed for replacement or service on a bench.

a. Removing Azimuth Drive Motor.

(*1*) Remove the panel of the antenna mount skirt over the drive motor compartment.

(*2*) Disconnect the power cable if necessary.

(*3*) Remove the bolts and nuts holding the motor in place.

(*4*) Lift the motor out of its mounting hole, taking care not to damage the neoprene gasket around the motor flange.

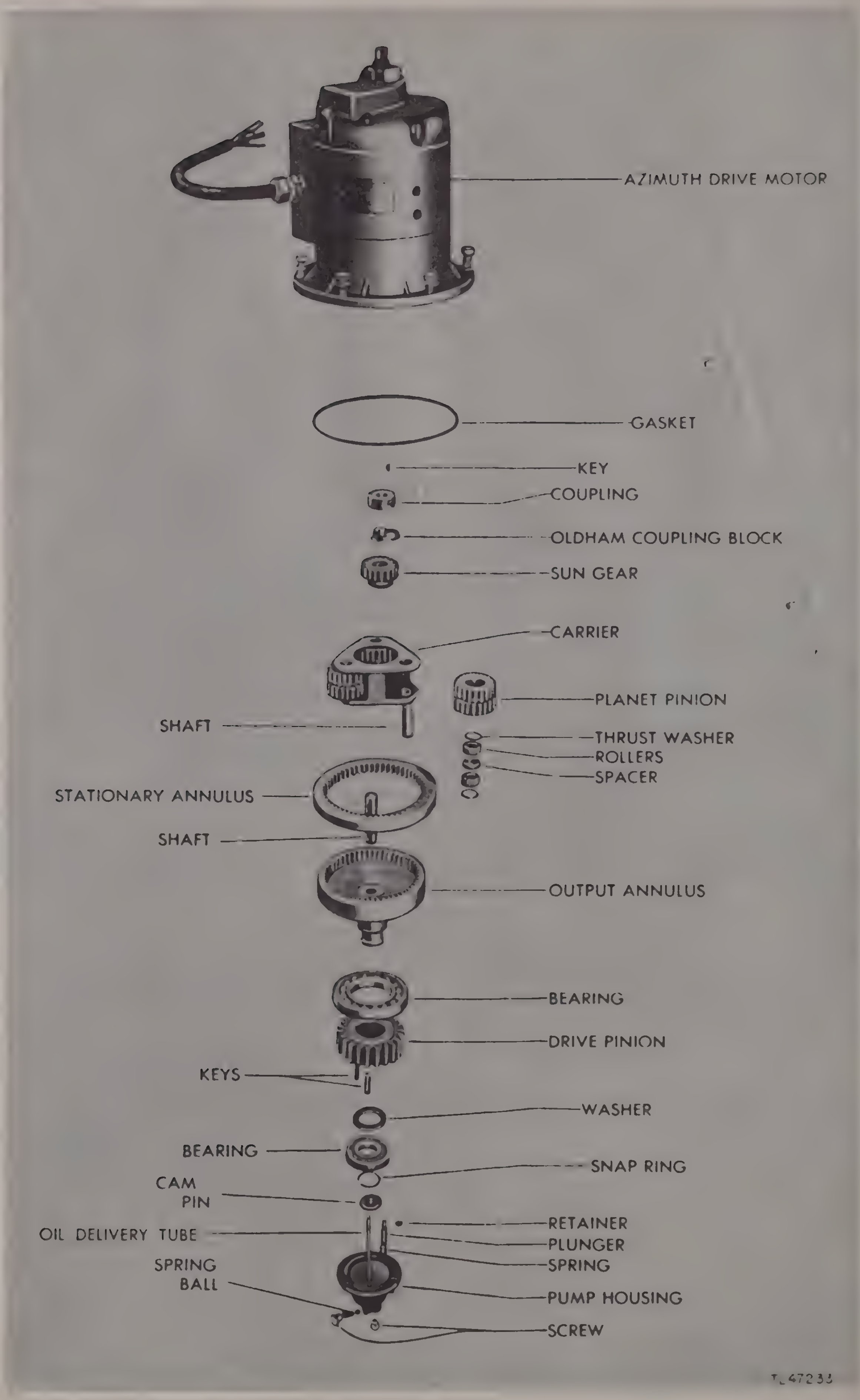


Figure 363. Azimuth drive train, exploded view.

b. Replacing Azimuth Drive Motor.

(*1*) To replace the drive motor, remove the inspection plug on the side of the motor housing.

(*2*) Turn the motor so that the flat side of the motor flange faces the center of the mount.

(*3*) Turn the motor shaft until the slots on the coupling fit over the tongue on the coupling block. The line-up of these elements can be observed through the inspection hole in the motor housing.

331. AZIMUTH DRIVE GEARS (fig. 363).

a. Removal.

(*1*) Remove the azimuth drive motor (par. 330**a**).

(*2*) Remove the Oldham coupling block, sun gear, planet pinion carrier assembly, and the stationary annulus. Use puller SL-17 for pulling the stationary annulus out of place.

(*3*) Remove the oil reservoir following the instructions in paragraph 329.

(*4*) Remove the oil pump housing. Loosen all three screws before removing any so as to allow the output annulus to move down slowly until it rests against the base. With the housing free of all weight but its own, it may be supported by one hand while the screws are taken out. The pump housing is full of oil and must be handled with care until taken to a place where it can be emptied. When the housing is emptied, be certain not to lose the loose parts of the pump.

(*5*) Using the snap-ring pliers, remove the snap ring from the outer race of the lower ball bearing.

(*6*) Remove the output annulus and attached parts through the motor pilot hole in the top of the base. While a second man removes the assembly, reaching down from the roof and holding on the bottom side of the output annulus teeth, stand inside the trailer and place a brass sleeve against the outer race of the bearing, Then tap the end of the sleeve with a hammer. Be careful to position the sleeve so that it clears the hole in the base. When the bearing is free of its bore, the annulus and attached parts may be lifted from the azimuth base and carried to a convenient place for disassembly.

b. Disassembly.

(*1*) Using a hammer and chisel, cut and remove the wires locking the planet gear shafts in the carrier. Grip the carrier assembly gently in a vise, the jaws of which are covered with sheets of brass or other soft metal to protect the gripped parts. Set the vise against the parallel faces of the carrier at a point where any compression of the carrier is borne by the heavy bars running between the two faces. To remove a planet pinion, place dummy shaft SL-10 against the flat end of the pinion shaft and drive the pinion shaft out. This shaft prevents the rollers of the bearing from falling out of place as their shaft is displaced. As soon as shaft SL-10 clears the carrier wall, pull out both the pinion and dummy shaft from the carrier. Remove the two retainer rings, the rollers, and the center spacer from shaft SL-10, and set them aside with the planet gears. Repeat this procedure on the other two planets.

(*2*) The azimuth oil pump cam is held by a light press into the end of the annulus hub. To remove the cam, set the point of a chisel against the cam where it joins the hub and tap gently with a hammer, moving the chisel around for successive taps. When the cam has been moved out sufficiently, insert a screwdriver behind it and pry it out of the hub.

CAUTION: Do not twist the cam in removing it, thereby causing damage to the drive pin.

(*3*) The lower ball bearing can be removed with the azimuth oil-pump cam either on or off, since the outer diameter of the cam is slightly less than the hub diameter. To remove the bearing, first remove the snap ring with the snap-ring pliers. Then insert the blade of a screwdriver radially between the drive pinion and the outer race of the bearing, and pry the bearing by twisting the blade of the screwdriver.

(*4*) Remove the drive pinion with gear puller SL-7. Care must be taken to prevent the loss of the two keys that become loose as the gear is removed.

(*5*) Remove the upper ball bearing by inserting a drift pin through the holes in the output annulus and against the inner ball-bearing race, driving the bearing from the shaft.

c. Reassembly.

(*1*) The upper ball bearing is assembled first. Place the annulus on a flat surface, with the hub up. Center the bearing at the eage of the hub section on which it must installed. Set a brass bar against the inner race to get the bearing started straight. Once started, the tapping can be made somewhat harder, but should be distributed around the race until the bearing is fully seated.

(*2*) The drive pinion may be tapped on. Lay the pinion keys in place on the hub before replacing the gear on the hub.

NOTE: Be sure that the tapped holes in the pinion are away from the annulus gear and toward the end of the hub. Otherwise the puller cannot be used to remove the pinion.

(*3*) Place the washer on the shaft after the pinion is installed. In placing the lower ball bearing on the annulus hub, be sure that the groove in the outer race of the bearing is on the side away from the drive pinion. Then replace the bearing by the method used on the upper bearing. When the bearing is seated, spread the small snap ring and slide it over the hub and into the groove adjoining the bearing. Be sure the ring is seated in the groove.

(*4*) To replace the oil-pump cam, first line up the drive pin with the hole provided for it in the end of the hub and then use a mallet to tap the cam into the hub.

(*5*) Lay a planet pinion on its side on a clean, smooth surface, drop the first retainer ring to the bottom of the hole in the pinion, and insert the dummy shaft. Then insert the rollers, one at a time, after dipping them in cup grease. A clean wooden or metal pointer of small diameter is useful in moving the grease covered rollers into place. After the first set of rollers is in place, insert the wide center spacer and repeat the above procedure with the second set of rollers, placing a retainer ring on top.

(*6*) Place the pinion in the carrier. Drive in the pinion shaft, displacing the dummy shaft. Take care that the holes for the locking wire line up in the carrier and shaft. The dummy shaft is near enough to the diameter of the pinion shaft to space rollers properly and is short enough to slide into the carrier.

(*7*) Repeat the above procedure with the other two planet pinions. Be certain to have all of the 19-tooth planets on the sun gear side of the carrier. After all three pinions are in place, insert a new locking wire in each shaft. To lock the shafts in position, bend the wires with a chisel and hammer.

(*8*) Place the output annulus and attached parts in place in the azimuth base.

(*9*) Replace the snap ring and oil pump assembly on the bottom of the output annulus assembly. The flat side of the oil pump body faces the main drive gear.

(*10*) Replace the sun gear and the planet pinion assembly, following closely these directions:

(*a*) Lay the carrier on a flat surface so that the 19-tooth planets are on top. It is found that one of the teeth on each of the 19-tooth planets lines up perfectly with a tooth on the 18-tooth end of the planet. Move this tooth on each planet out away from the center of the carrier, so that it lies on a straight line passing through the carrier center and the planet shaft. Face the carrier so that one planet is on your left, another on your right, and the third directly across from you. Place a mark to locate a tooth on the 18-tooth planet of the left gear, and then rotate the gear clockwise exactly six teeth, counted on the 18-tooth gear.

(*b*) Perform the same operation on the right-hand gear, but turn it six teeth counterclockwise. Note that both planets are rotated toward the remote gear, around their outer rim. Now drop the sun gear into mesh with the 19-tooth planets. If the planets have been perfectly aligned, the sun gear drops into mesh without the planet teeth moving. Small amounts of misalignment may be overcome by moving the planets slightly.

(*c*) Now slip the carrier planets and sun gear assembly over the end of the shaft projecting from the output annulus and bring the teeth of the 18-tooth planets to the face of the output annulus. If the aligning procedure has been followed accurately, the planets slide into mesh with the teeth of the output annulus. If the gears are tight, they may be rolled into mesh by turning the sun gear.

(*d*) Do not attempt to force the gears into mesh as they may jam. It is very difficult to get them free again. If they do not line up, it is necessary to start over again.

(*e*) The stationary annulus is the last gear to install. It meshes with the 19-tooth planets if the sun gear is in mesh with them. Slide it into its position in the azimuth base and into mesh with the planets.

332. AZIMUTH OIL PUMP.

When the pump housing has been removed from the azimuth base, as described in paragraph 331, empty the oil from the pump housing, being careful not to let the pump plunger, spring, and retainer escape. These parts are held in place by contact of the plunger with the cam, and can be removed simply by inverting the housing and catching them in the hand. The retainer is C-shaped and may be removed from the plunger by moving the plunger sideways out of the eye

of the C. The ball and spring in the discharge valve may be disassembled by removing the screw which retains it.

333. AZIMUTH SELSYNS.

The azimuth selsyns may each be removed as follows:

a. Remove the door on the azimuth selsyn compartment (fig. 364) and set the safety switch to the SAFE position.

b. Remove the panel over the compartment by taking out the 14 cap screws holding it to the housing.

c. Disconnect the wires leading to the selsyn to be removed.

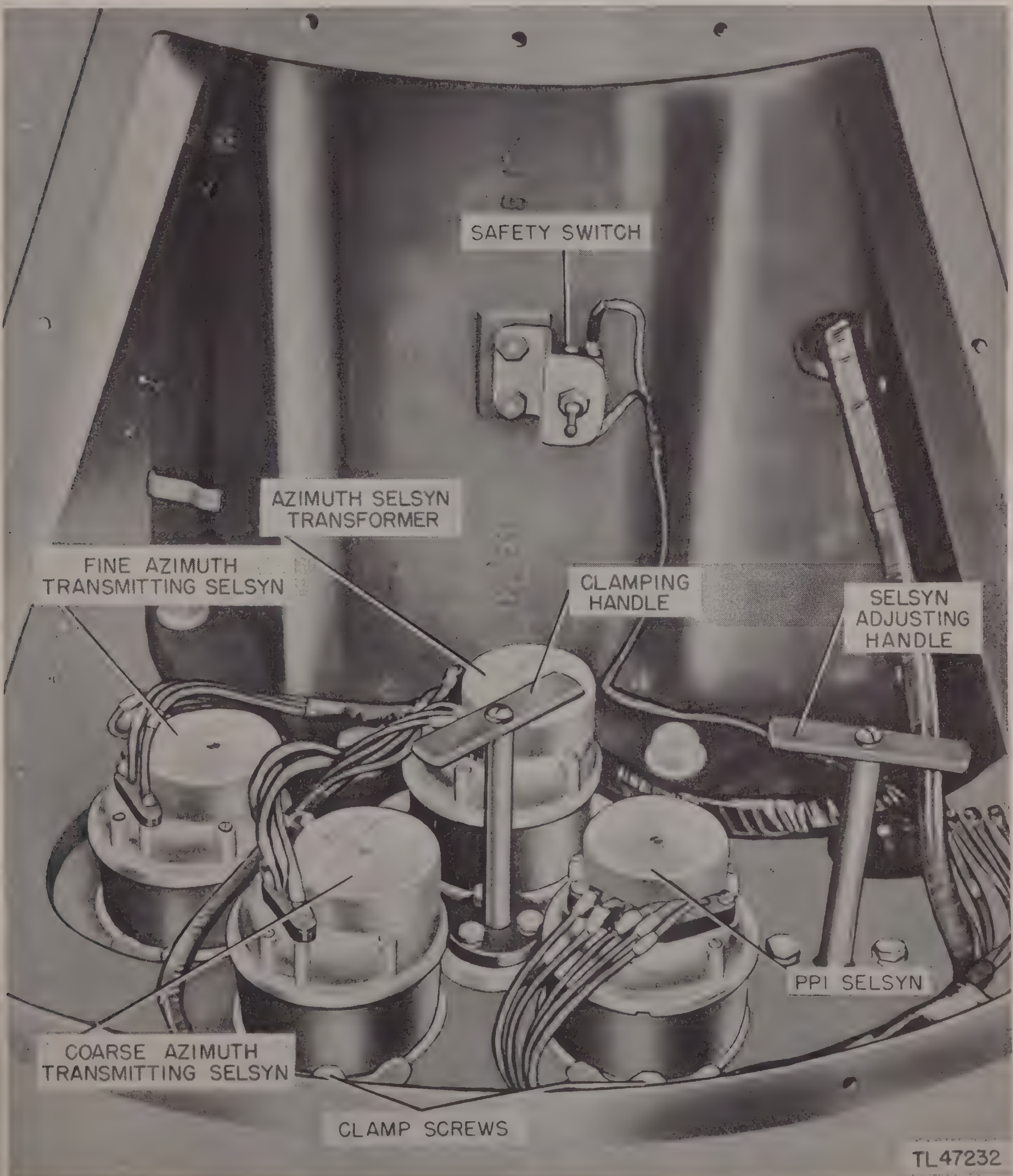


Figure 364. Azimuth selsyn compartment.

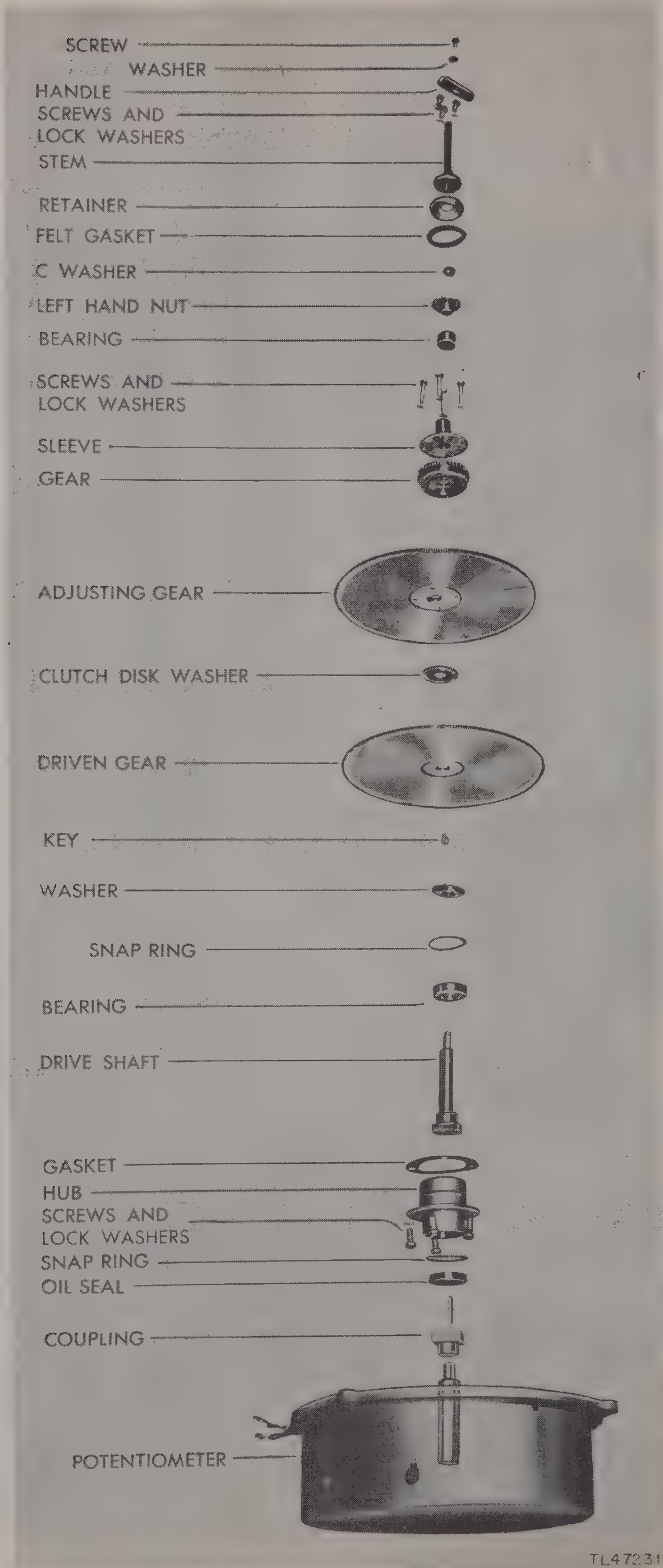


Figure 365. Azimuth selsyn drive train, exploded view.

d. Remove the screws holding the two clamps on the selsyn.

e. Lift the selsyn vertically upward to bring its gears out of mesh and up through the hole in the azimuth base, and remove it from the compartment.

f. Remove the gear from the selsyn shaft as follows:

(*1*) Remove the nut and lockwasher on the end of the selsyn shaft.

(*2*) Hook gear puller SL-6 over the rim of the gear and screw the ram against the end of the shaft. Tighten the ram until the gear is pulled off.

334. AZIMUTH SELSYN DRIVE TRAIN. (fig. 365).

The complete disassembly of the azimuth drive train requires considerable skill and should ordinarily be undertaken only in a base depot.

a. Remove the door to the selsyn compartment and set the safety switch S2001 to the SAFE position.

b. Remove the panel over the compartment by taking out the 14 cap screws holding it to the housing.

c. Remove the clamps holding the selsyns in place. Set the selsyns aside on the top of the azimuth base without disconnecting the wires.

d. Turn the selsyn clamping handle counterclockwise until it is loose.

e. Remove the clamping handle assembly by removing the three screws at the base of the stem.

f. Lift off the retainer and felt gasket.

g. Push the C washer sideways out of the groove in the upper end of the selsyn drive shaft.

h. Unscrew and remove the left-hand nut by turning it clockwise.

i. Remove the oil reservoir and cover assembly. The steps are all described fully in paragraph 329.

j. Remove the azimuth main drive gear.

(*1*) Remove the snap ring below the gear on the azimuth drive shaft, using snap-ring tool C-484. This ring becomes visible when the large transmission line clamping nut is removed from the shaft.

(*2*) Attach gear puller SL-6 to the drive gear by inserting the screws in the tapped holes in the gear and bringing the ram of the puller against the end of the azimuth drive shaft.

(*3*) Remove the gear by tightening the puller slowly, and rapping the head of the ram screw with a hammer.

NOTE: The main drive gear and the selsyn input gear are bolted together and so are removed together. The flat washer may drop down with the gears, or may catch on the shaft undercut. In the latter event, remove the washer to prevent its being accidentally dislodged later. Remove the felt seal.

k. Remove the hub and selsyn gears.

(*1*) Remove the four screws fastening the hub to the azimuth base. Ease the hub, drive shaft and attached parts down until the selsyn driven gear rests on the flange of the azimuth base forming the bottom of the gear compartment.

(*2*) Pull downward on the hub. The shaft moves down until the end of the key reaches the top of the clutch disk. The keyways in the top gears are in line, since these gears are bolted together. The keyway in the clutch disk may not be in line with those in the gear. Reach into the case from below and rotate the lower gears very slowly in the opposite direction. When the key slips through the clutch disk, put a little downward pressure on the hub and rotate the two gears as before, until the key slips into the keyway of the lower gear. The hub and shaft assembly now drop free and are taken to a bench, for further disassembly.

l. Remove the stack of gears still remaining in the gear case through the azimuth drive shaft hole. A slight pressure should be maintained between the gears during their extraction to keep the clutch disk from sliding out and escaping.

m. Disassemble the gears by removing the four screws, holding sleeve and selsyn drive gears together.

n. The needle bearing that supports the selsyn drive shaft at its top end may be removed from the counterbore in the azimuth base by pushing or tapping it down through the bore.

o. Disassemble the hub and selsyn drive shaft.

(*1*) Remove the key and slip the washer off the top end of the shaft.

(*2*) Press shaft downward through the ball bearing and the seal in the hub.

(*3*) Remove the ball bearing from the hub by prying the top snap ring out of its groove, pushing the bearing out with a round bar. Be careful not to damage the seal with the bar.

(*4*) Push the oil seal out through the bottom of the hub, with a wooden block.

(*5*) Remove the bottom snap ring with a screwdriver.

p. Remove the azimuth selsyn adjusting handle.

(*1*) Remove the two screws securing the adjusting handle to the azimuth base.

(*2*) Lift the adjusting handle assembly vertically until the pinion clears the hole in the azimuth base.

(*3*) Remove the spring from the hole in the base.

(*4*) Set the stem in a vise and tap out the pin retaining the adjusting pinion on the stem. Pull the pinion off the stem.

(*5*) Take out the screw and withdraw the handle.

335. AZIMUTH DRIVE SHAFT (fig. 366).

The azimuth drive shaft is removed by following the procedure given below. A number of components must be removed first before the azimuth drive shaft is accessible.

a. Remove the reflector, proceeding as follows:

(*1*) Turn the reflector until it faces the front of the trailer and tilt it to an elevation of 20 degrees.

(*2*) Remove the antenna.

(*3*) Remove the three bottom bolts holding the reflector to the reflector support using a 7/8-inch open-end wrench.

(*4*) Loosen the five upper bolts, using a 7/8-inch socket wrench.

(*5*) While two assistants steady the reflector, remove the five bolts and lift the reflector clear of the spinner motor assembly.

b. Remove the spinner motor assembly as described in paragraph 353.

c. Remove the elevation drive case as described in paragraph 346 subparagraphs **a** through **h**.

d. Remove the elevation hub by removing the six bolts fastening the hub to the elevation yoke and drive the hub out of the yoke by tapping the hub evenly from the inside of the elevation selsyn compartment.

e. Remove the elevation selsyn drive shaft (par. 348**c**).

f. Lift the reflector support from the elevation yoke.

g. Remove the elevation yoke as follows:

(*1*) Remove the spider bracket supporting the r-f transmission line. Unfasten the connector at the top of the azimuth drive shaft and remove the section of line above the connector.

(*2*) Disconnect all wires from TB7, TB8, TB9, and TB10 coming out of the azimuth drive shaft.

(*3*) Unfasten the terminal board brackets and push them, with all the outgoing wires attached, away from the azimuth drive shaft.

(*4*) Attach a chain fall to the elevation yoke using chain SL-13. Hook the chain in the holes in the ears projecting from the top of the elevation yoke and pull the hoist taut.

(*5*) Remove the six mounting screws that attach the elevation yoke to the azimuth drive shaft and hoist the yoke off the drive shaft.

h. Screw two eye bolts SL-11 into opposite holes in the drive shaft flange and hook on to them with a chain fall. Pull up snugly.

i. Remove the oil reservoir as described in paragraph 329.

j. Remove the main drive gear as described in subparagraph 334**j**.

k. Remove the cover from the brush and slip-ring compartment and remove the cap screws holding terminal boards TB1 and TB2 to the pedestal. Swing the boards out to bring the brushes clear of the slip-ring insulator.

l. With wrench SL-8 remove the bearing retainer nut from the lower end of the drive shaft. Remove the washer and slide the cone of the roller bearing off the shaft.

m. Hoist the drive shaft out of the azimuth pedestal and move it clear of the azimuth base. Keep the shaft vertical so as not to damage the insulating rings.

n. Follow the reverse procedure when reassembling. When tightening the bearing retainer nut use wrench SL-8 and apply a torque of 80– or 90– foot pounds. No clearance is permissible in the bearings.

o. To remove the slip rings raise the support far enough to free the four pins. After removing the pins lower the slip rings and insulators in a stack.

336. AZIMUTH STOWING LOCK.

a. Remove the azimuth stowing lock (fig. 360) from the top flange of the housing as follows:

(*1*) Remove the housing panel that is just below the lock.

(*2*) Remove the two screws securing the bracket to the housing from the lower side of the upper flange of the azimuth pedestal.

(*3*) Lift the bracket and stowing lock off the stowing switch plunger.

(*4*) Remove the stowing switch plunger from the hole in the housing.

b. Drive the pin out of the handle.

c. Push the handle and shaft into the bracket,

and press the lock back away from the snap ring in the shaft. Remove the snap ring.

d. Pull the shaft and handle out of the lock and nut.

e. Pull the lock out of the bracket.

f. Unscrew the nut from the bracket.

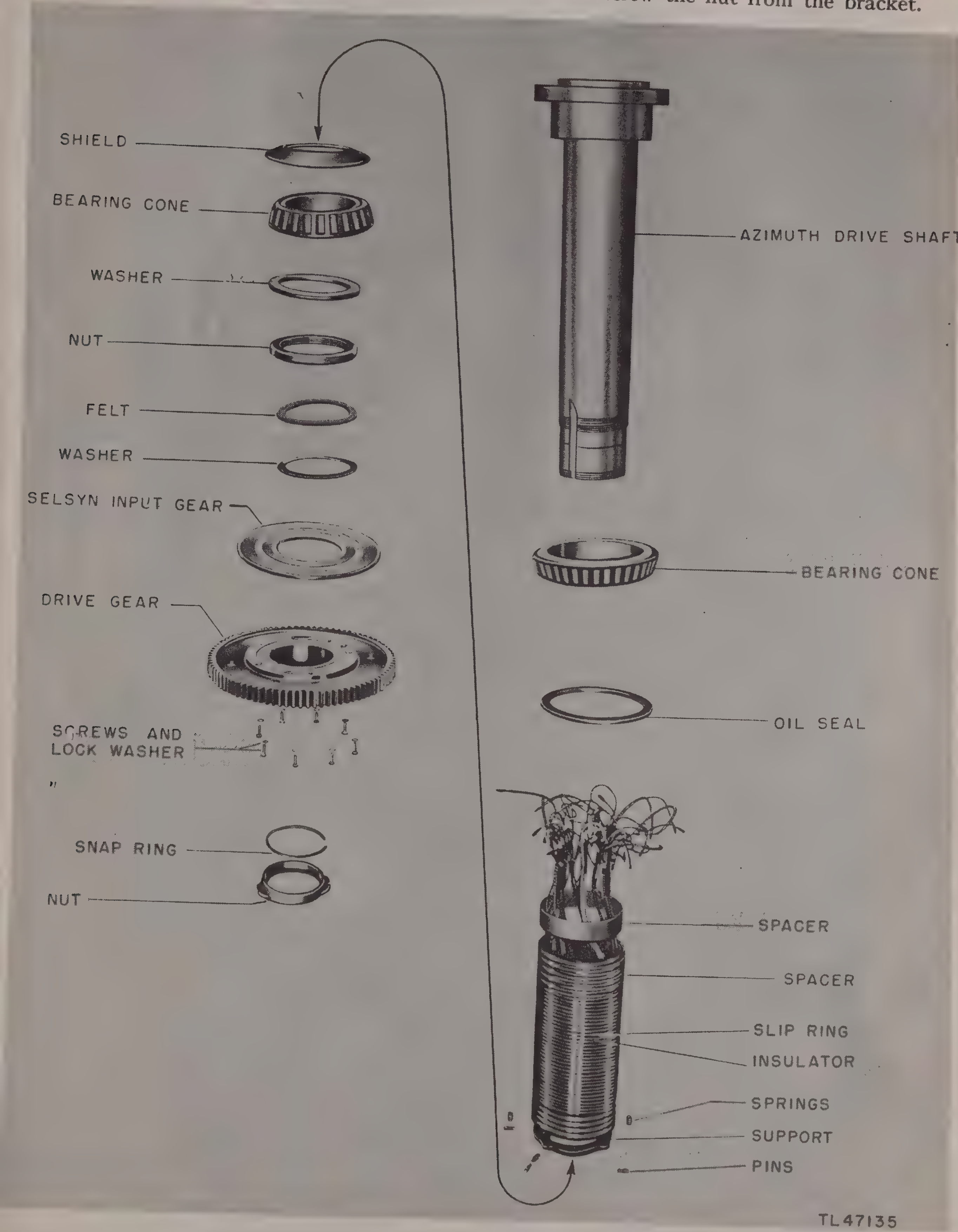


Figure 366. Azimuth drive shaft, exploded view.

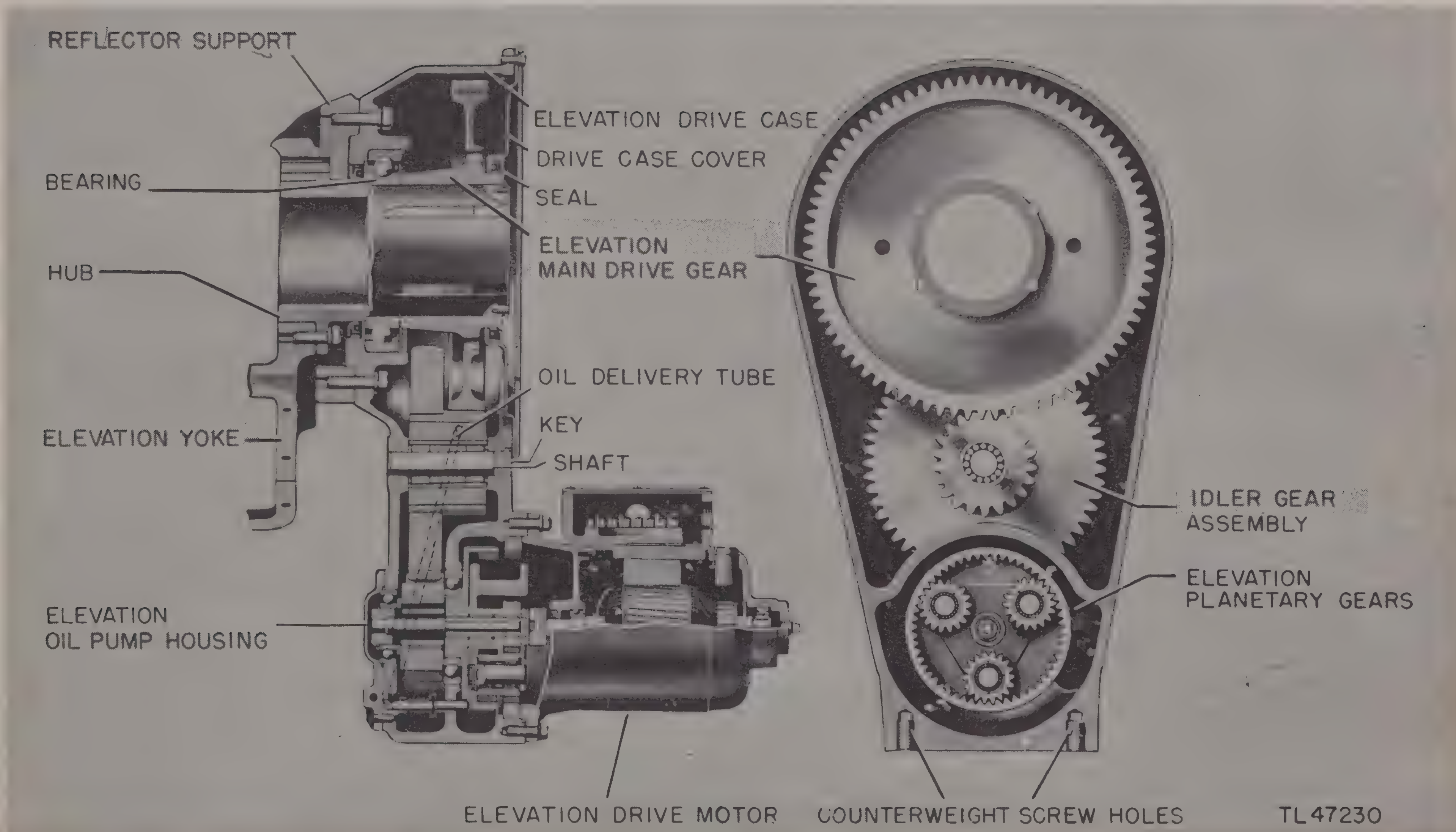


Figure 367. Elevation drive train, cutaway view.

CHAPTER 23
ELEVATION YOKE ASSEMBLY

SECTION I
DESCRIPTION

337. ELEVATION DRIVE TRAIN.

a. Location. The elevation drive motor and reduction gearing are shown in figure 367. A plan view is shown in figure 368. This assembly includes the drive motor, the idler and drive gears, and the oil pump. Unlike the azimuth drive assembly which is mounted on a stationary base and drives a shaft, these parts are all contained in the elevation drive case, a movable case which drives itself around a stationary hub.

b. Drive Motor. The elevation drive motor is identical to the azimuth drive motor. However, additional reduction gears are provided in the elevation drive train; so the antenna rotates more slowly in elevation than it does in azimuth. The reflector travels from its lower limit to its upper limit, a total of 101.5 degrees. To produce this amount of rotation of the antenna, 304 revolutions of the elevation drive motor are required. If the drive motor were run at its top speed of 3,600 rpm, the time required for the antenna to go from one limit to the other would be 5.08 seconds. Obviously, the motor operates below top speed during normal operating conditions.

c. Oldham Coupling and Reduction Gears. The Oldham coupling and the reduction gears are identical to those used in the azimuth drive assembly with the exception of the output annulus. The elevation output annulus has a 6-lobe cam cut in its surface and does not have a pin hole in its hub. The drive pinion, keyed to the output annulus, does not mesh with the drive gear, but the speed is reduced by a compound idler gear which couples it to the elevation drive gear. This idler gear turns at a speed of 12.4 rpm when the drive motor runs at 3,600 rpm. The 21-tooth gear of the idler meshes with the 78-tooth elevation main drive gear which is fixed; the idler climbs around it, raising or lowering the drive case and the reflector support attached to it.

d. Elevation Oil Pump. The planetary gears, drive pinion, idler gears, bearings, and the drive gear are lubricated by the elevation oil pump. The pump is operated by the cam surface on the output annulus. As the annulus turns, it alternately pushes and releases the pump plunger, which is held against it by a spring. As the pump

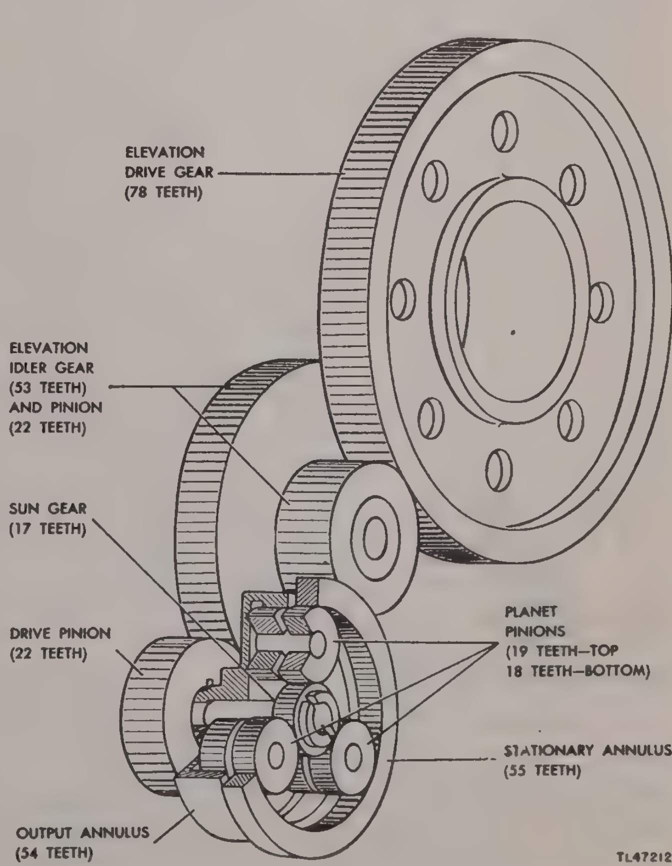


Figure 368. Elevation drive train, plan view.

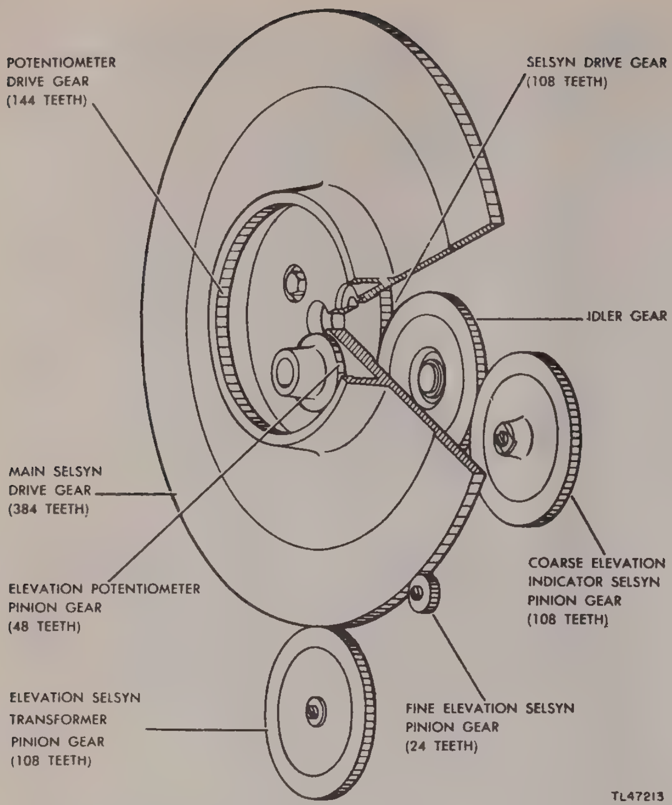


Figure 369. Elevation selsyn drive train, plan view.

plunger is released from its hole, it draws oil through a hole and check valve in the pump housing. When the cam forces the plunger back into its hole, the oil drawn in is forced out through another check valve into the oil delivery tube where it is carried up to the idler gear. The oil flows over the idler gear and drips down over the gears and bearings in the elevation drive case and back in the bottom of the case where it is recirculated by the pump. The oil pump is shown in the cutaway view (fig. 367). The pump is not shown in its true position in these illustrations. The position shown was selected in order to show the action of the pump. Actually, the pump housing is placed so that the oil intake hole is located near the oil level plug; so oil is at the level of the intake hole regardless of the position of the elevation drive case.

338. ELEVATION HUB.

The elevation hub serves two important purposes. It carries the reflector support and the whole elevation drive case, and it provides a mounting for the elevation main drive gear. The hub is bored out to a 4-inch inside diameter to accommodate the r-f transmission line. A counterbore is provided at the outer end for piloting the flange of the r-f line housing.

339. ELEVATION SELSYNS AND POTENTIOMETER DRIVE TRAIN.

a. Location. The elevation selsyn drive train (fig. 370) is located on the end of the elevation yoke opposite the elevation drive case. The drive train consists of the elevation selsyn drive shaft, selsyn and potentiometer drive gears, the three selsyns, the elevation potentiometer, and the selsyn adjusting arm. The selsyn drive shaft is fastened to the reflector support and turns with it, whenever the reflector is tilted by the elevation drive motor.

b. Elevation Selsyn Drive Shaft. The elevation selsyn drive shaft (fig. 371) provides the support for one end of the reflector support. One end of the shaft extends through a seal into the elevation selsyn compartment. A cam is fastened to the end of this shaft to trip the elevation limit switches. The other end of the shaft is mounted in a ball bearing in the yoke and holds the two selsyn drive gears. The adjusting arm clamps around the shaft and causes it to turn with the reflector support. A set of screws and locknuts permits the shaft to be turned without turning the yoke. This adjusting arm performs the same function as the orienting and locking handles in the azimuth selsyn drive train.

c. Elevation Selsyns. The three elevation selsyns are mounted inside the selsyn compartment (fig. 372) with their ends projecting into the selsyn-gear housing. Two clamps bear on the shoulder of each selsyn. The coarse elevation indicator selsyn pinion gear (fig. 370 and 369) has 108 teeth. This gear meshes with an idler gear between itself and the 108-tooth drive gear on the selsyn drive shaft. The main drive gear on the selsyn drive shaft has an internal gear of 144 teeth and an external gear of 384 teeth. The external teeth mesh with the 108-tooth gear on the shaft of the elevation selsyn transformer and the 24-tooth pinion on the fine elevation indicator selsyn. With these gears, the selsyn transformer turns through an angle which is 3⁵⁄₉ times as great as the angle of tilt of the reflector; and the fine elevation indicator selsyn turns through an angle 16 times as great as that of the reflector. The three elevation selsyns are capable of being turned through an unlimited number of turns in either direction, but their actual travel corresponds to the angle of tilt of the reflector multiplied by the gear ratio to each unit. Thus,

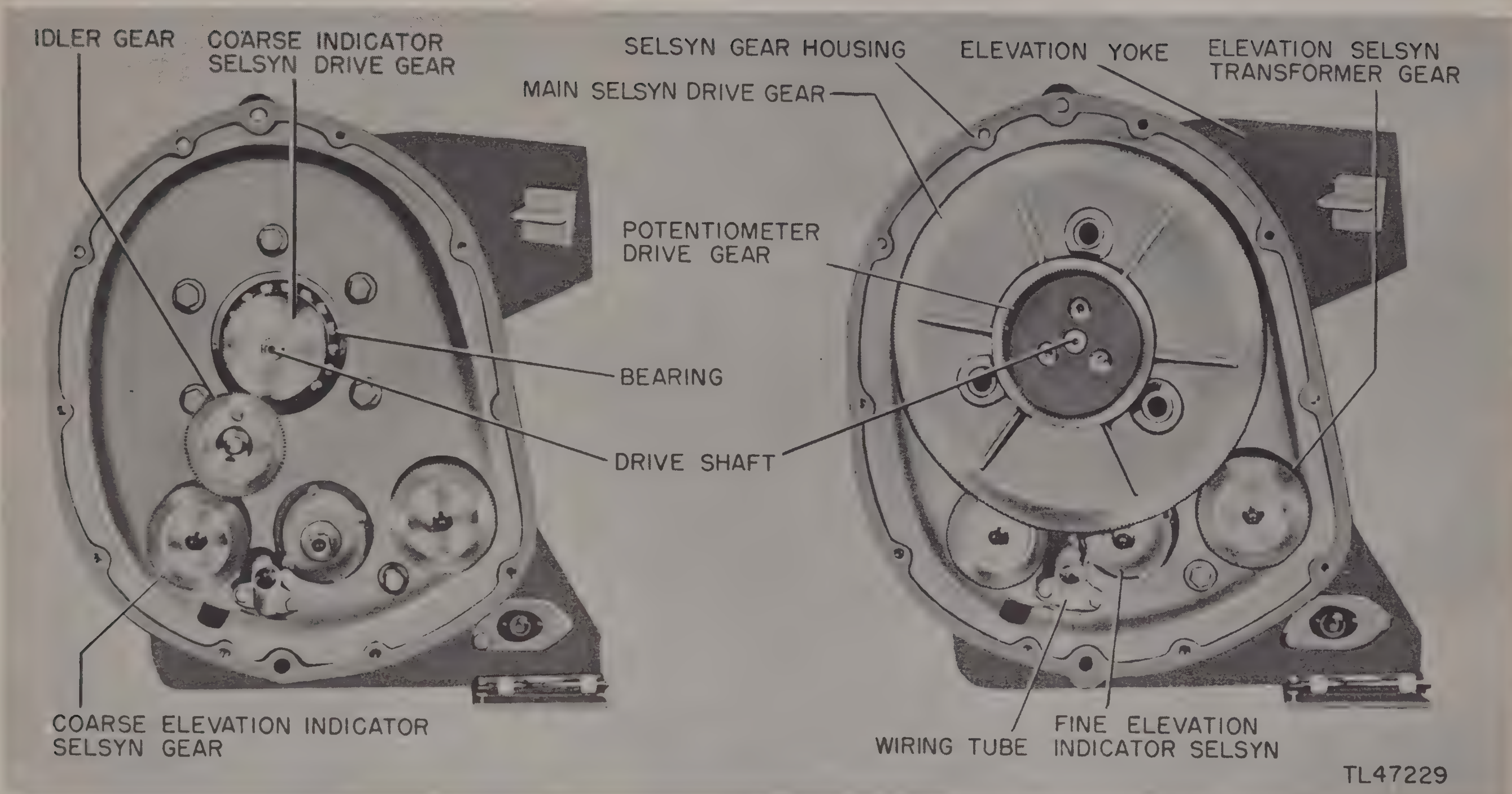


Figure 370. Elevation selsyn drive gears.

since the reflector can be tilted only between metal-to-metal stops 101½ degrees apart, the 1 to 1 coarse elevation indicator selsyn is limited to an angular travel of 101½ degrees. The elevation selsyn transformer may turn 3$\frac{5}{9}$ times 101½ degrees, or 360 degrees, while the 16 to 1 fine elevation transmitting selsyn may turn through 1624 degrees, or approximately 4½ revolutions.

d. Elevation Potentiometer. The 48-tooth elevation potentiometer anti-backlash gear meshes with the internal teeth of the elevation selsyn main drive gear. The gear ratio is such that the potentiometer turns through an angle three times as large as the angle of tilt of the reflector. The maximum possible turning angle is three times 101½ degrees, or 304½ degrees. Slots in the mounting lugs extending from the outside of the potentiometer frame permit an angular adjustment of 6 degrees of the potentiometer frame. A large curved slot in the potentiometer mounting plate permits the wires from the elevation gear housing to pass into the potentiometer.

340. ELEVATION LIMIT SWITCHES.

The elevation limit switches serve to turn off the power to the elevation drive motor when the reflector reaches the lower limit and the upper limit of its excursion in elevation. As shown in figure 373, the plungers that throw the switches on and off are controlled by a cam attached to the elevation selsyn drive shaft, which turns with the reflector. The elevation limit switches are mounted on a circular mounting plate secured to the yoke wall by screws which pass through slotted holes in the mounting plate and allow a circumferential adjustment of the plate of about 9 degrees. The turning of the plate is accomplished by the eccentric mounting plate cam. Each elevation limit switch is mounted on its side on an adjusting plate. The adjusting plate fastens to the mounting plate by two screws. One of these screws provides a pivot. The other fits a hole that is elongated to permit the microswitch to be moved toward or away from the cam. Another hole in the adjusting plate, located just opposite to and in line with the switch foot, fits the head of the switch adjusting pin. The head of the pin has a screwdriver slot for adjusting the switch position.

341. ELEVATION STOPS.

a. Description. The amount of travel of the reflector in elevation is limited first by the elevation limit switches and then by the elevation stops (fig. 374). The elevation stop mechanism consists of a lever, two bumpers, and two compression springs. The two bumpers are mounted 107½ degrees apart on the reflector support. The lever is mounted on the yoke beneath the elevation hub. The two compression springs are mounted in chambers near the lower part of the yoke. Each chamber contains a spring button, and a compression spring backed up by a plug. These two spring chambers are located so that the longer lower arm of the lever rests between the two spring buttons. The upper arm of the lever is in a position to be struck by the bumpers on the reflector support.

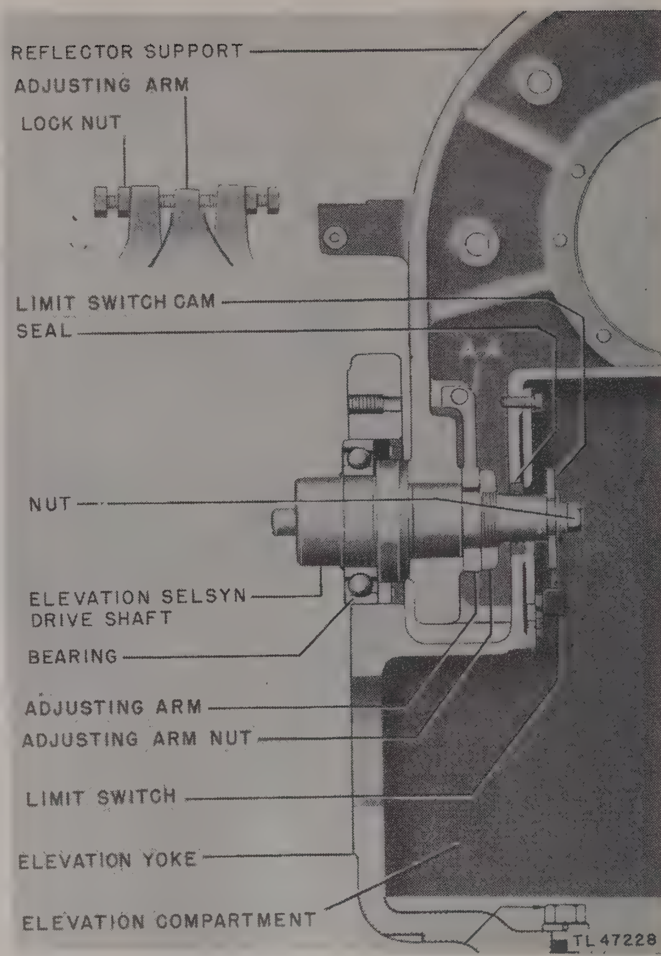


Figure 371. Elevation selsyn drive shaft.

b. Operation. When properly adjusted, the elevation limit switches should cut off the elevation drive motor 3 or 4 degrees below the horizon and 85 degrees above the horizon. After the limit switch operates, the mechanism will coast. The bumpers on the reflector support strike the lever after 3 or 4 degrees of coast. Each shock spring can be compressed ½ inch before reaching its solid height, at which point the spring load is approximately 1,900 pounds. The actual

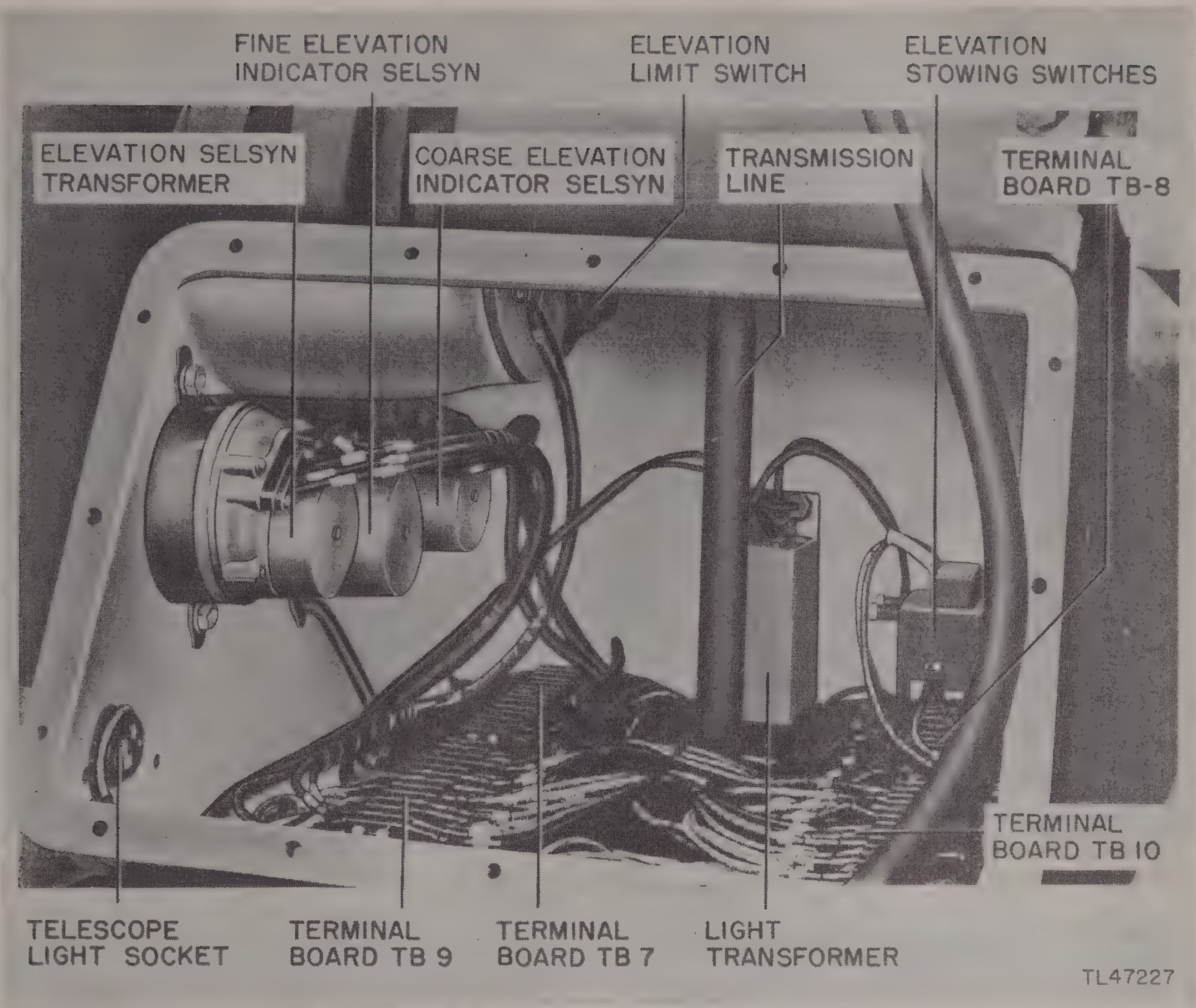


Figure 372. Elevation selsyn compartment.

retarding force applied on the bumper on the reflector support is multiplied by the lever to about 2,950 pounds.

342. ELEVATION STOWING LOCK.

An elevation stowing lock, shown in figure 375, is provided to keep the reflector support and reflector assembly in place and to protect the gears of the elevation drive train when the pedestal is in its stowed position. The lock is mounted on the upper side of the elevation drive case and screws against the end of the elevation yoke. A locking plunger, pressed inward by a spring, bears against the thread of the handle or against the shaft depending on whether the handle is screwed in or out. Once the pin has dropped in against the shaft, the handle cannot be screwed in until the pin is raised against the spring pressure.

343. ELEVATION STOWING SWITCHES.

The elevation stowing switches serve as protective devices to prevent the operation of the elevation drive motor when the reflector is

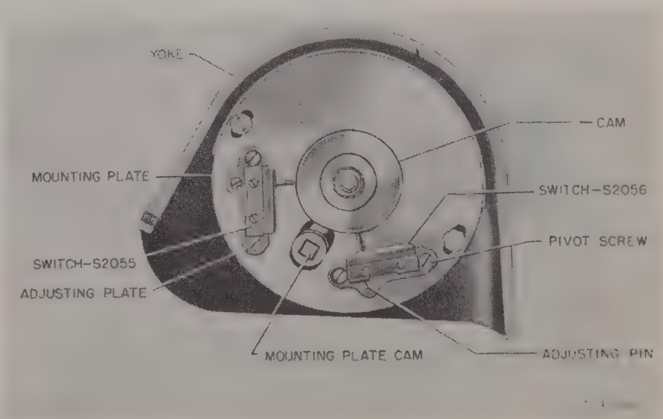


Figure 373. Elevation limit switches.

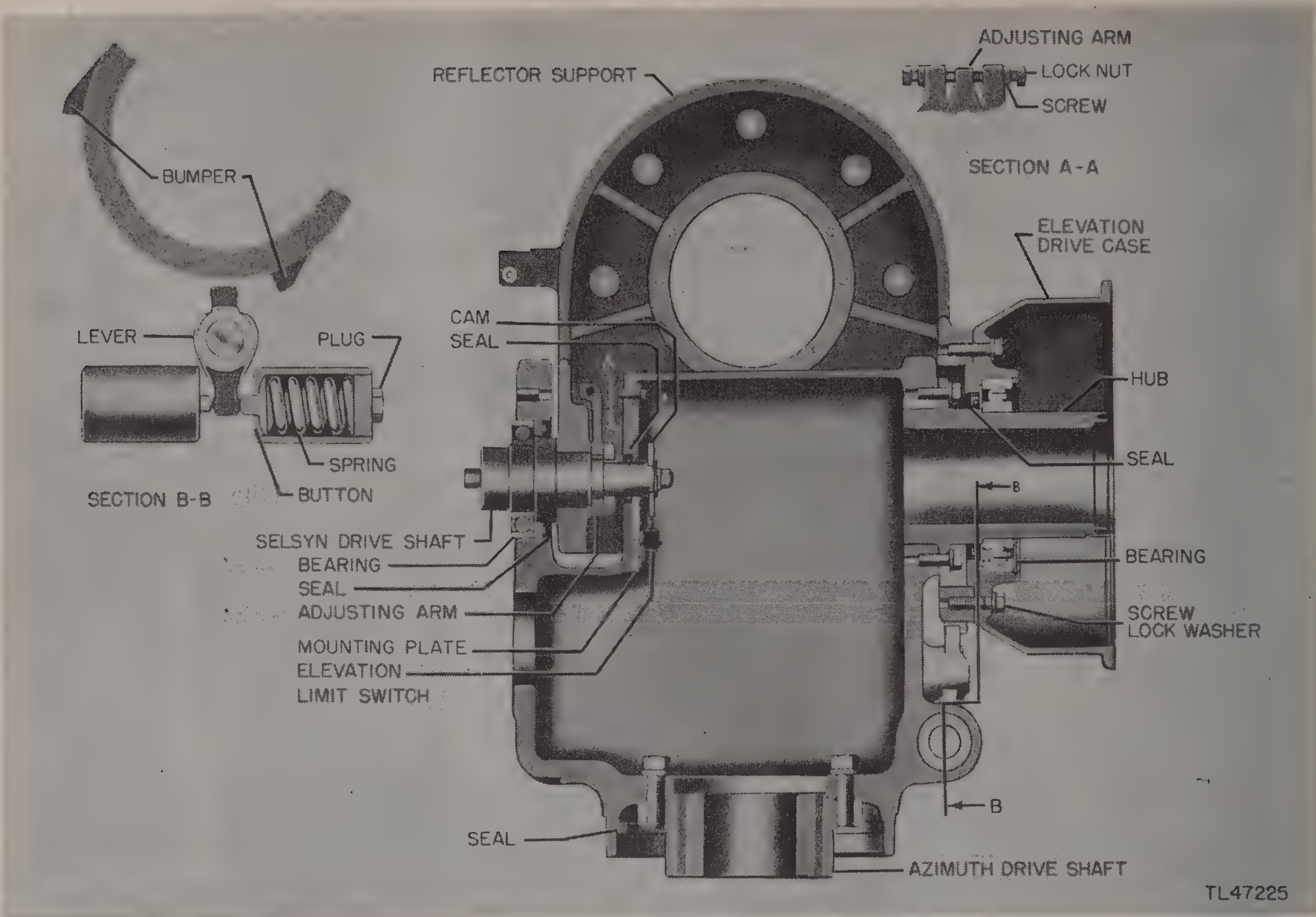


Figure 374. Elevation stops.

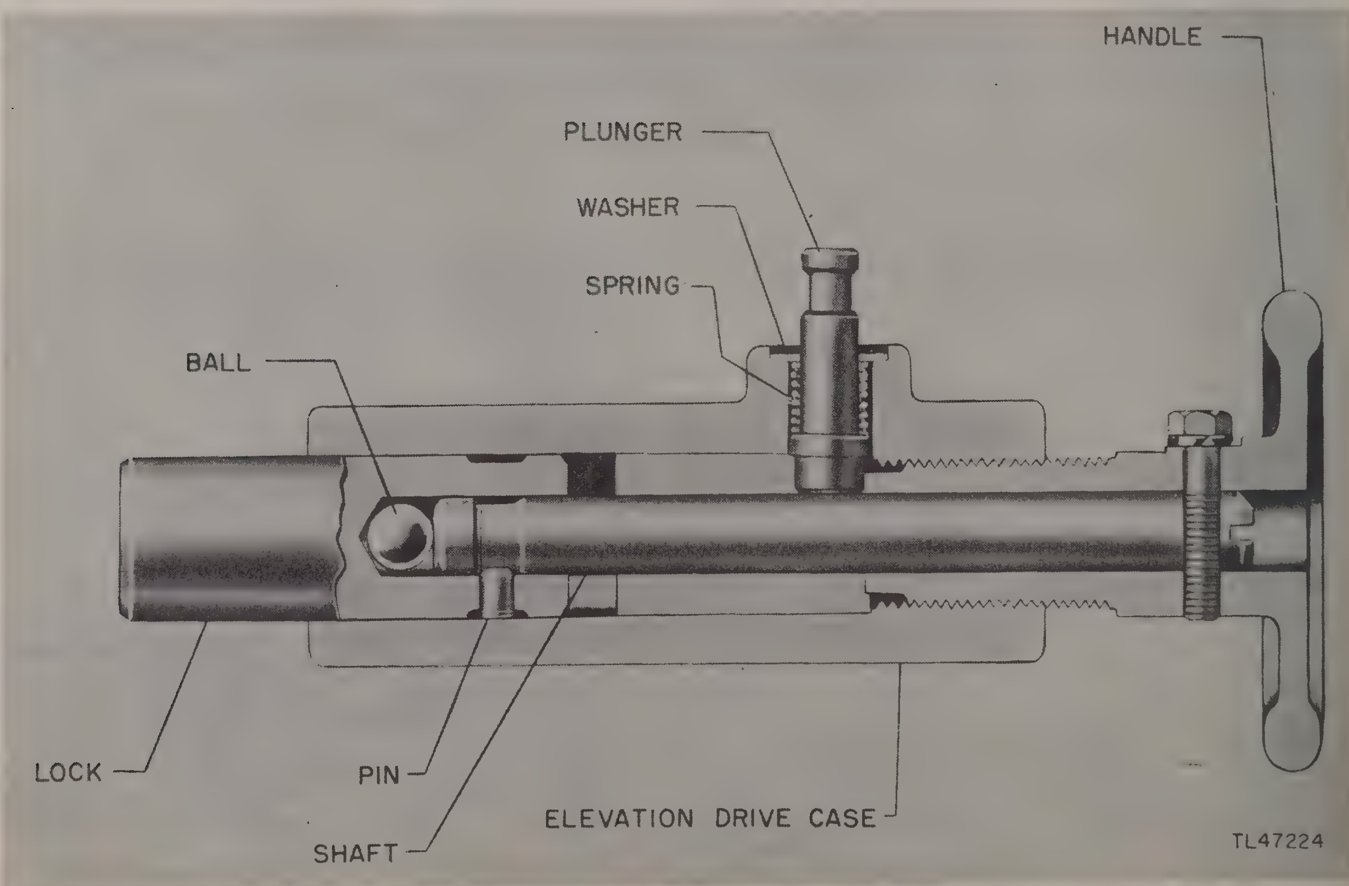


Figure 375. Elevation stowing lock.

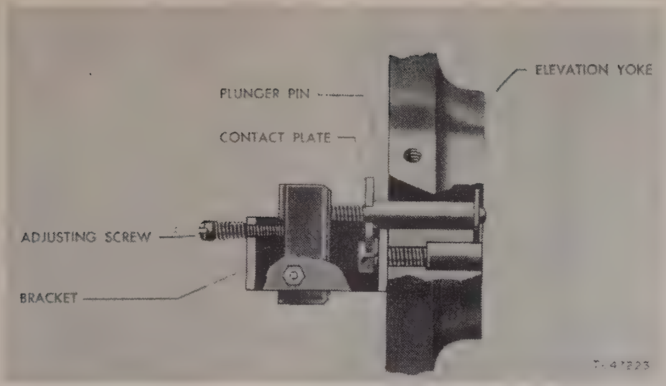


Figure 376. Elevation stowing switches.

locked in its stowed position. The switches are operated by the action of the elevation stowing lock. When the lock is "in", it strikes against a plunger which, as indicated in figure 376, extends through a hole in the wall of the elevation yoke. Each elevation stowing switch rests against its own adjusting screw. The springs between contact plate and the switches press the switch bodies snugly against the end of adjusting screws, thus holding the switches in position but leaving them free for adjustment.

344. TELESCOPE MOUNT.

a. The telescope is used during the process of orienting and synchronizing Radio Set SCR-784 with the gun director. It is mounted on the reflector support where its axis can be conveniently aligned with the electrical axis of the reflector. The mounting assembly is made up of three parts, the mounting bracket, the swivel

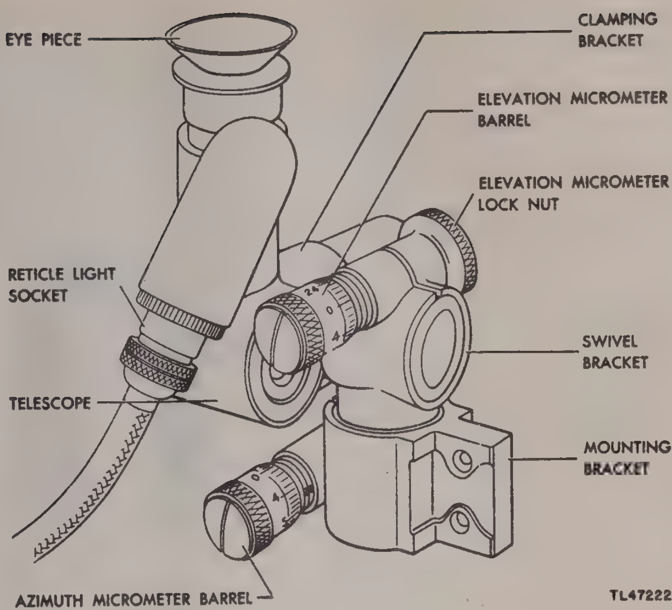


Figure 377. Telescope mount.

bracket, and the clamping bracket. These are shown in figure 377.

b. Two micrometers on the telescope mount permit the axis of the telescope axis to be moved a small amount to coincide with the reflector axis. The construction of these micrometers is shown in figure 377. Turning the micrometer screw in the mounting bracket clockwise one graduation produces a counterclockwise azimuth rotation of the telescope of 1 mil. Turning the swivel bracket micrometer screw one graduation clockwise raises the telescope through 1 mil in elevation.

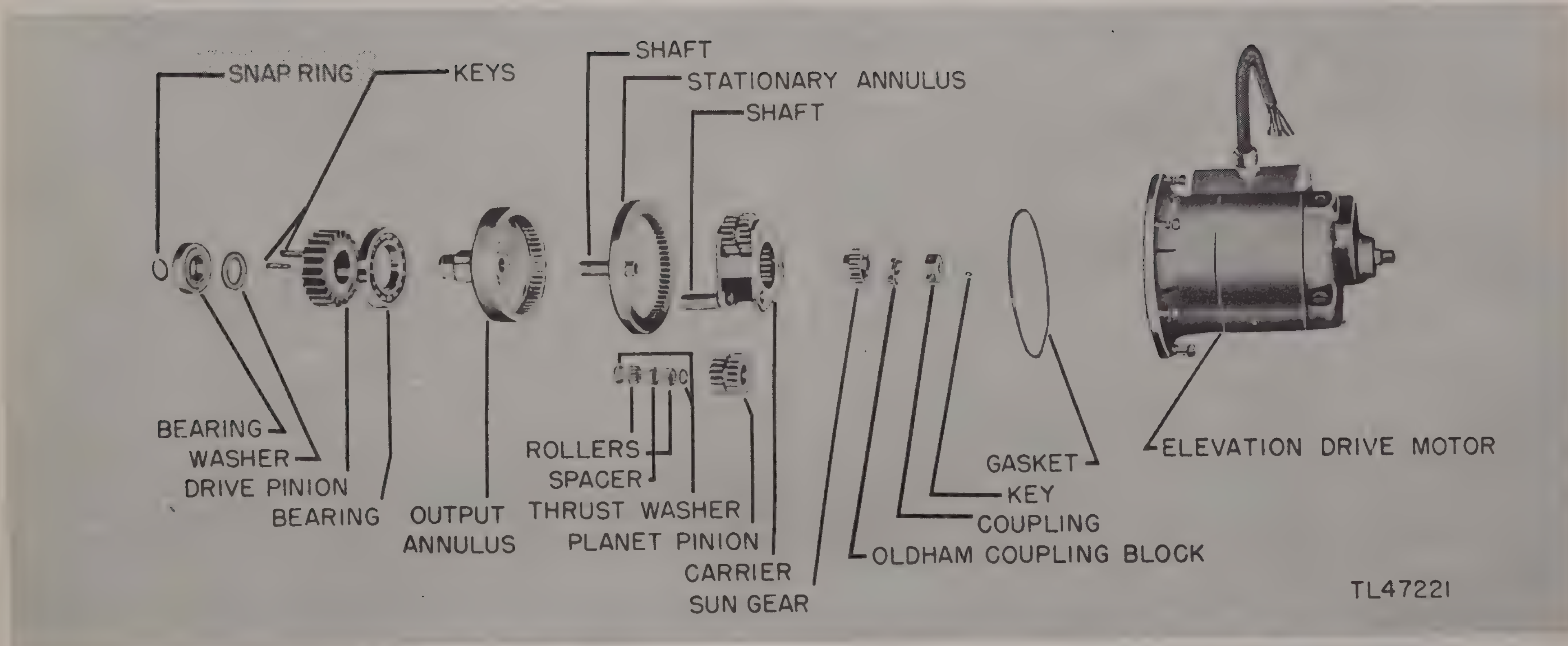


Figure 378. Elevation drive train, exploded view.

SECTION II

DISASSEMBLY

345. ELEVATION DRIVE TRAIN (fig. 378).

a. Remove the drive motor.

(*1*) Set the antenna to 75 degrees elevation and drain the oil from the elevation drive case.

(*2*) Disconnect the power cable to the motor.

(*3*) Place a block of wood between the front wall of the elevation yoke and the reflector to keep the reflector from dropping when the motor is removed.

(*4*) Remove the screws and the bolt that hold the drive motor. Lift the motor, being careful not to damage the gasket around the shoulder of the motor.

b. Remove the reduction gears and oil pump.

(*1*) Remove the Oldham coupling block, sun gear, planet carrier, and stationary annulus follwing the procedure given for the corresponding parts in the azimuth drive gears (par. 331).

(*2*) Remove the elevation oil pump from the side of the elevation drive case. Be careful not to lose the ball check valve and springs that become loose when the pump body is removed from the drive case.

(*3*) Remove the snap ring from the outer race of the ball bearing and push the output annulus with its attached parts out of the drive case.

(*4*) Disassemble the planetary gears following the procedure given for the corresponding parts in the azimuth drive gears (par. 331).

c. Replace the drive train following the assembly procedure for the planetary reduction gears in paragraph 331**a**.

346. ELEVATION DRIVE CASE (fig. 379).

For purposes of removing and disassembling the elevation drive case, the reflector must be pointing straight out and a block must be placed under the reflector support to keep it from dropping. After removing the elevation drive motor and the planetary gear, proceed as follows:

a. Remove the counterweight from the lower end of the drive case.

b. Remove the elevation drive motor (par. 345**a**).

c. Disconnect the r-f transmission line at the joint near the line's entrance to the elevation hub inside the elevation selsyn compartment and behind the spinner motor. Remove the screws holding the transmission line flange to the end of the hub. Then carefully withdraw the uncoupled section of line from the hub.

d. Remove the cover from the upper end of the drive case.

e. With special tool C-484 remove the snap ring, which retains the main drive gear.

f. Pull the main drive gear off the hub, using puller SL-6. The two keys may come off with the gear or remain on the hub.

g. Attach a chain hoist to the drive case end of the reflector support, and draw up snugly. The hoist chain may be looped around the reflector support over the big ring flange where it is bolted to the drive case. The purpose of the hoist is to support the weight that is ordinarily carried by the ball bearing between the drive case and the hub, so that when the drive case is removed, severe twisting action on the bearing at the opposite side of the yoke may be prevented.

h. Remove the screws attaching the elevation drive case to the reflector support. Pull the drive case and bearing from the hub, using puller SL-16.

i. Remove the idler gear assembly from the drive case, as follows: Press out, or drive out, the idler shaft using dummy shaft SL-9 against the end of the shaft that does not bear the key. Remove the key from the shaft, using pliers if necessary. Slide the idler gear upward and withdraw it from the case through the large hole at the upper end. Keep the bore of the gear as nearly horizontal as possible so that the roller bearing parts will not spill out.

j. Remove the elevation stowing lock (fig. 375) by first removing the screw which retains the handle on the shaft. Unscrew the handle until it is free of the case. Then pull the lock and

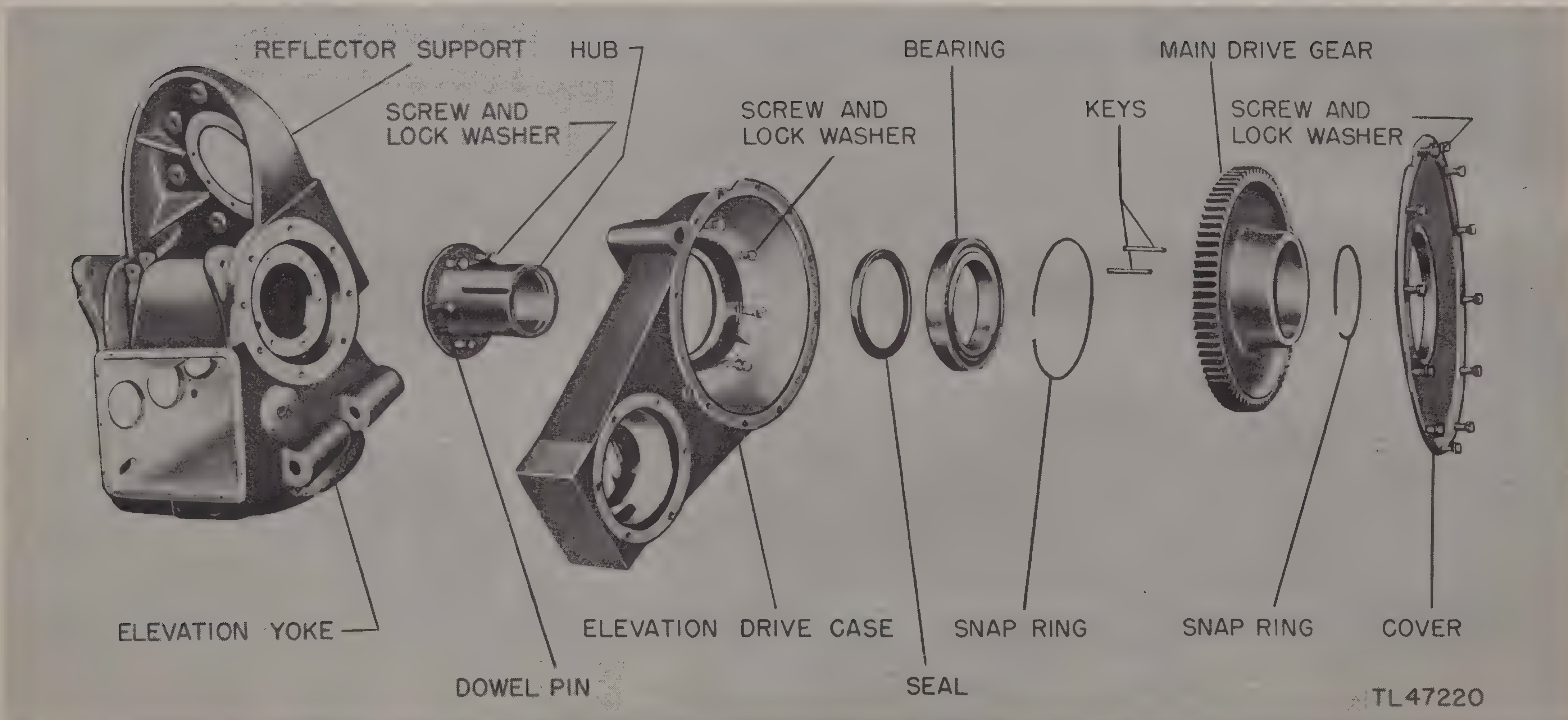


Figure 379. Elevation drive case, exploded view.

shaft out from the opposite side of the case. The pin retaining the lock on the shaft is a free fit in its hole. Remove it, and pull the shaft out of the lock. Tip up the lock and catch the ball as it rolls out. If it is necessary to remove the spring loaded plunger from the drive case, push the plunger and spring into the hole as far as possible and move the end of the plunger over to the side of the hole under the retaining washer. Insert a screwdriver through the hole in the washer and pry the washer out of the hole. Withdraw the plunger and spring from the hole.

k. Remove the large ball bearing from the drive case by first removing the snap ring. After the snap ring has been removed, the bearing and the seal may be removed by pressing or tapping them out of the bore.

347. ELEVATION POTENTIOMETER.

a. Removal. To remove the elevation potentiometer, disconnect the leads to the potentiometer from terminal board TB7, (fig. 372), remove the bolts holding the potentiometer to the yoke, and pull the potentiometer and wires out of place. If it is necessary to remove the potentiometer anti-backlash gear, hold the gear with tool SL-20 and remove the nut from the end of the shaft with wrench SL-21.

b. Installation. When replacing the elevation potentiometer, care must be taken so that the potentiometer arm will not strike the stops within the travel of the reflector in elevation.

(*1*) One method which may be used to obtain the proper setting is to turn the potentiometer drive shaft until the arm hits the stop corresponding to the lowest position of the reflector, mark this position on the potentiometer case, and then turn the shaft to the other end of travel and mark the case again. Locate the center of travel, halfway between the marks. Similarly, locate the mid-point of travel of the reflector and set the reflector at that point. Install the potentiometer, engaging the gear on the potentiometer shaft so that the potentiometer shaft is set at the mark corresponding to the mid-point of its travel. Final adjustment of the potentiometer is made by means of the procedure described in paragraph 302 **a**.

(*2*) Another method of securing the proper setting of the potentiometer arm with respect to the reflector is to drain the potentiometer of oil, remove the sheet metal cover from the potentiometer, and set the finger on the potentiometer arm to the zero position. The position is indicated by the dot on the case. Then install the potentiometer with the reflector at zero degrees elevation angle.

348. ELEVATION SELSYN DRIVE TRAIN.

a. Elevation Selsyns. The elevation selsyns are removed by disconnecting the leads to them, and removing the clamps that hold the selsyns in place. The pinion gears on the selsyn shaft are small enough to be withdrawn through the selsyn mounting hole.

b. Elevation Selsyn Drive Gears (fig. 380).

(*1*) Remove the cover of the elevation selsyn gear housing with the potentiometer attached. When replacing the potentiometer follow the instructions in paragraph 347.

(*2*) Remove the three screws holding the selsyn drive gears and remove those gears from the shaft.

(*3*) Remove the idler gear by first removing the snap ring and washer that hold it in place.

c. Elevation Selsyn Drive Shaft (fig. 380).

(*1*) Remove the nut, lockwasher, washer, and the elevation limit switch cam (fig. 371) from the end of the drive shaft. When replacing the cam, the label TOP FRONT should be at the top facing into the compartment.

(*2*) Hook on to the reflector support with a hoist chain or rope, to take the weight load off the drive shaft.

(*3*) Remove the elevation adjusting arm nut (fig. 371) from the threads on the drive shaft, using wrench SL-12.

(*4*) Relieve the lock screw pressure on the upper end of the adjusting arm by loosening the lock nuts and backing off the screws slightly.

(*5*) Tap the drive shaft and bearing out of the reflector support and on through the yoke and gear housing. Catch the adjusting arm and nut as they fall off the end of the shaft.

(*6*) Remove the ball bearing by first removing the snap ring with pliers and screwdriver, and then tapping or pressing the bearing off the shaft.

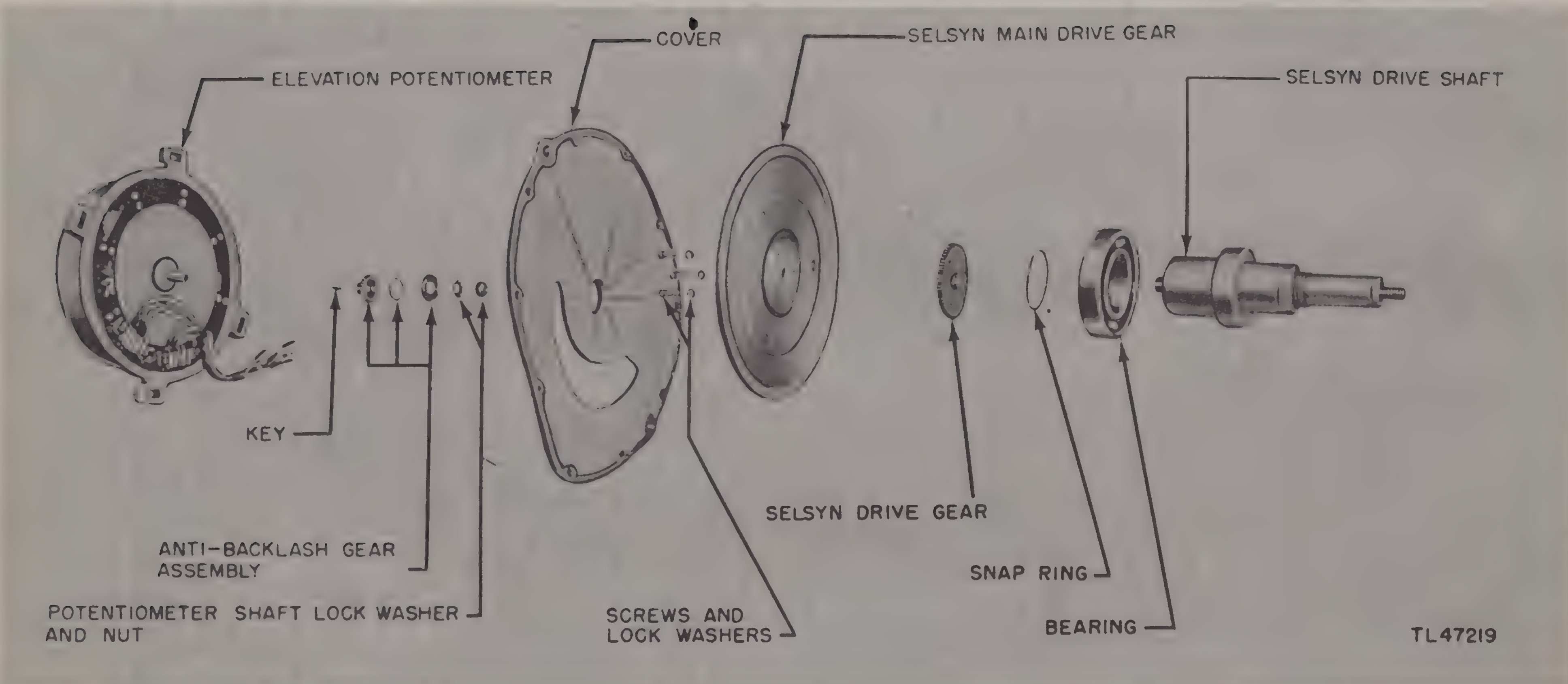


Figure 380. Elevation selsyn drive train, exploded view.

CHAPTER 24
SPINNER MOTOR AND GENERATOR ASSEMBLY

SECTION I
DESCRIPTION

349. SPINNER MOTOR AND GENERATOR.

The spinner motor and generator assembly (fig. 381) has two principal parts, a motor and a generator. The motor is a 115-volt, 3-phase, 1,800-rpm induction motor. It spins the dipoles of the antenna whenever the set is on the air. The generator produces a 30-cycle voltage called the reference voltage when it is driven at 1,800 rpm by the spinner motor. The armature shaft of the motor generator assembly is hollow to hold the r-f line and the high speed rotary r-f joint. The whole assembly is contained in a metal housing that is bolted to the reflector support.

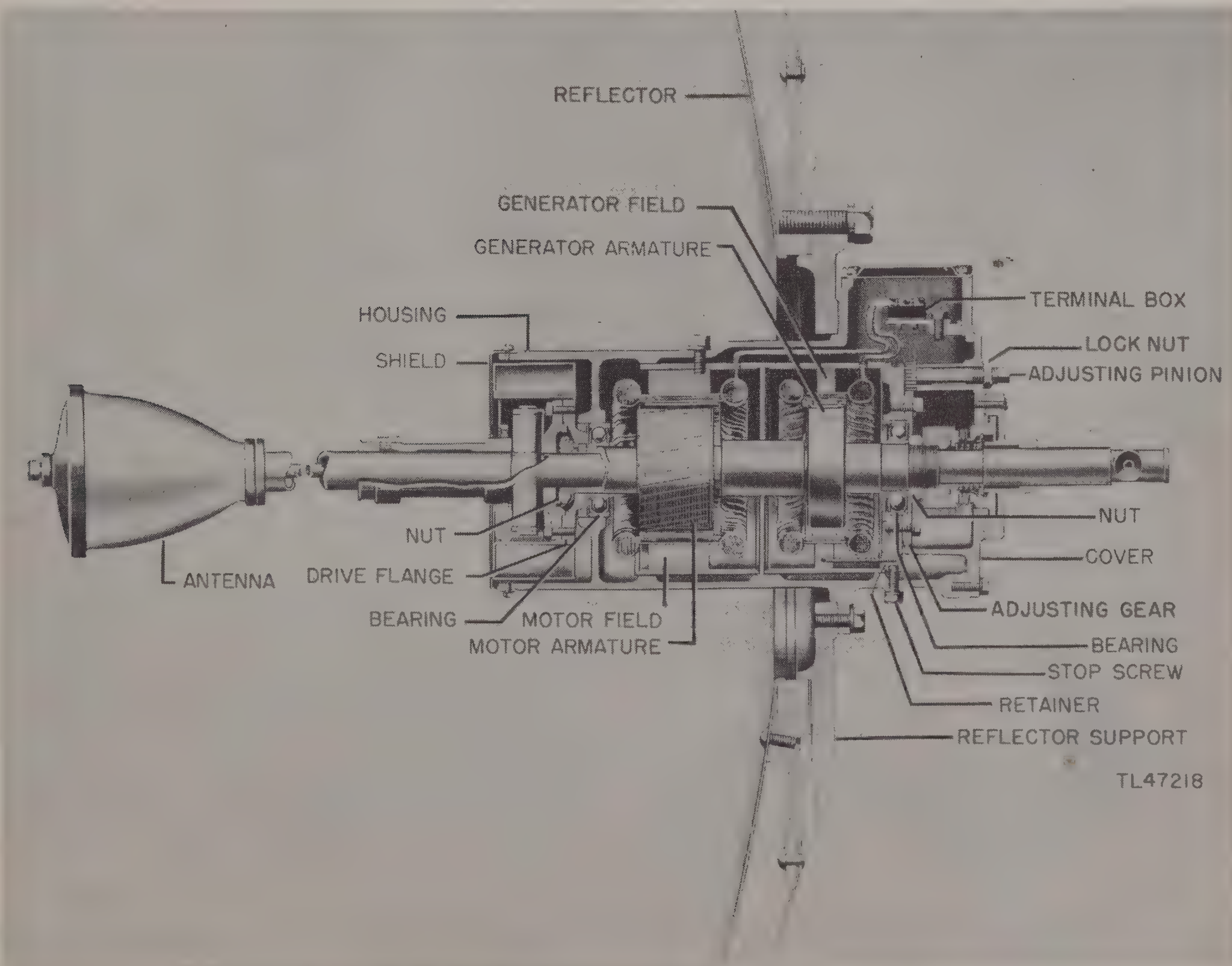


Figure 381. Spinner motor and generator, cutaway view.

350. FIELD COILS.

The field coils of the motor and generator are placed side by side in the housing with the motor field in front (fig. 381). The motor field is locked in place by a screw that extends through the housing. The generator field coils are mounted in the housing in such a way as to allow them to be turned so that the phase of the generator voltage can be aligned with the position of the dipole antenna.

351. ADJUSTING GENERATOR FIELD.

The field of the generator is contained in a sleeve which fits the inside of the housing (fig. 381). A retainer and adjusting gear are bolted to the rear of this sleeve. A stop screw that extends through the housing engages a slot in the retainer and holds the generator field in place. A pinion extending through the rear of the cover of the housing meshes with the adjusting gear. This pinion is locked in place with a locknut. The clamped pinion holds the generator field at any desired angular position between the stops provided by two pins in the groove in the retainer. These pins are spaced 100 degrees apart. At the ends of their excursion, they strike the stop screw. The leads from the motor and generator fields are brought out to a terminal block in a compartment at the rear of the housing.

352. ARMATURES.

The motor and generator armatures are mounted on a hollow shaft carried in two ball bearings, one near each end of the shaft. A drive flange is keyed to the armature shaft just beyond the front bearing. The rotating part of the r-f line is bolted to this drive flange.

SECTION II
DISASSEMBLY

353. REMOVAL.

The procedure for removing the spinner motor and generator assembly is as follows:

a. Turn the reflector in azimuth until it faces the rear of the trailer, and then tilt it to an elevation angle about 20 degrees above horizontal.

b. If the spinner motor and generator assembly is to be removed from the reflector support but not taken from the pedestal, the wires serving it need not be disconnected. To disconnect the leads;

(*1*) Remove the cover from the terminal box on the generator housing, and disconnect the six wires from the motor and generator terminals.

(*2*) Loosen the nut on the clamp holding the cable on the outside of the terminal box, and pull the cable from the box.

c. Remove parts of the r-f transmission line as follows:

(*1*) Remove the antenna by unscrewing the locking nut and stow it in the place provided.

(*2*) Unfasten the connector in the r-f transmission line that is located nearest the outer end of the elevation hub and unfasten the connector in the line that is located back of the motor assembly.

(*3*) Remove the uncoupled section of line, and place it where it will not be damaged.

(*4*) Remove the six roundhead screws that fasten the r-f line flange to the rear cover. Take out the flange and put it aside in a safe place. The gasket between the cover and the r-f line flange may stick either to the cover or to the flange. Remove it so that it will not be damaged.

d. Remove the motor and generator assembly from the reflector support by removing the screws in the housing flange.

354. DISASSEMBLY.

When the spinner motor and generator assembly has been removed from the reflector support, it may be disassembled on a bench as follows:

a. Remove the snap ring at the rear by pinching the turned in ends of the wire together with pliers. The seal spring throws the ring and also the retainer out of the assembly when the ring is released; so hold one hand up close to the hole to stop the escape of these parts. Set aside the snap ring, retainer and spring.

b. Using special wrench SL-18 remove the seal assembly.

c. Remove cover from the rear end of the housing. The adjusting pinion is attached to the cover.

d. Lift out the carbon sealing ring carefully and set it aside where nothing will be laid or dropped on it and where it can be kept clean.

e. Remove the shield and r-f choke assembly from the front end of the housing by removing the two screws on the rim of the shield.

f. Have an assistant at the front end hold drive flange and the r-f flange with special wrench SL-19 to prevent the armature shaft from turning, and remove the nut on the rear end of the shaft with special wrench SL-15. A sleeve pilots on the nut and will probably stick to and be removed with it, since the rubber gasket between the parts becomes sticky from the heat of the motor. The nut will probably bring with it also the rubber gasket which lies between the nut and the end of the armature shaft. Remove both rubber gaskets from the metal parts. If any rubber sticks to the metal, remove it by careful scraping. If the centering ring does not come with the rubber gasket, slide it back off the shaft.

g. Again keeping the armature from turning by placing wrench SL-19 on the bolt heads of the drive flange, loosen and remove nut at the rear end of the armature shaft, using special wrench SL-14.

h. Disconnect the r-f line flange from the drive flange. Withdraw the r-f flange, along with the section of line inside the hollow armature shaft by pulling the flange straight out from the front of the housing.

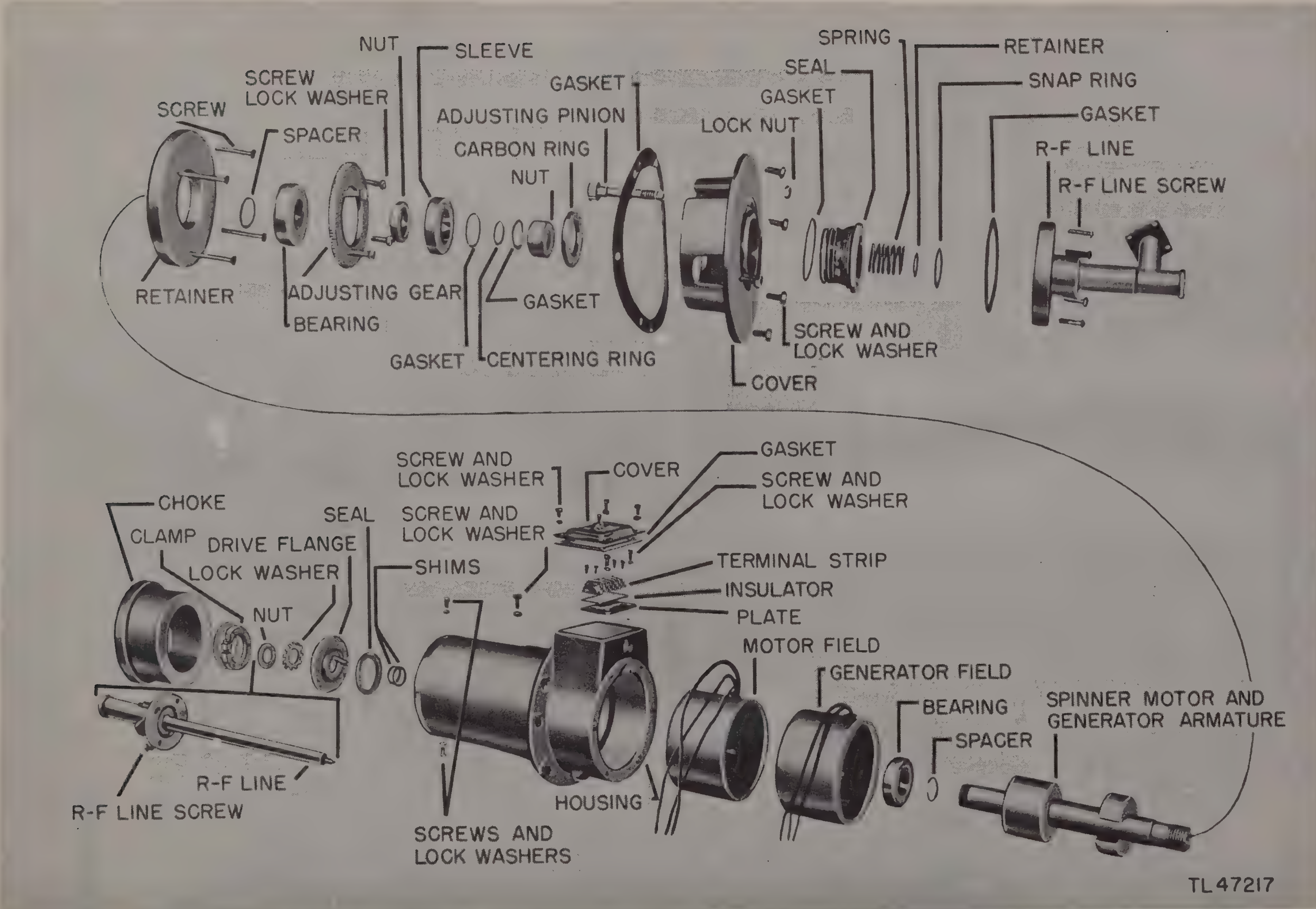


Figure 382. Spinner motor and generator, exploded view.

i. At the front end of the armature shaft, bend the locking tang of the lockwasher clear of the nut. Put the screws back in the drive flange and keep it from turning, with wrench SL-19. Use wrench SL-14 to unscrew the nut. Remove both the nut and the lock-washer.

j. Remove the drive flange and the key.

k. Remove the screws holding the generator field coil to the retainer plate and remove the stop screw.

l. Take the housing out of the vise and set it on end, with the front end up. Bump gently on the bench, if necessary, to free the armature shaft and ball bearing. Lift the housing off the armature assembly.

m. Remove the rear ball bearing with attached adjusting gear and retainer from the armature shaft, by bumping the end of the shaft on a wooden block or similar backstop. Slip the bearing spacer off the shaft. Remove the adjusting gear and retainer plate from the bearing by taking out the screws. If the parts fit the bearing tightly, insert a screwdriver between them and pry them apart.

n. Slip off (or tap off) the front bearing from the armature shaft and remove the spacer.

o. Disconnect the generator and motor wires from the terminals in the terminal box, and pull the generator field out through the rear of the housing.

p. Remove the screw which locks the motor field coil in the housing and pull the coil and sleeve assembly out through the rear of the housing.

q. Remove the dust seal from the front bearing bore of the housing by tapping on it from the rear.

355. ASSEMBLY.

The reassembly and installation of the spinner motor and generator assembly may be accomplished by reversing the steps outlined in paragraph 354. The following points require special mention:

a. The motor field coil must be installed with the tapped hole indexed with the hole in the housing. The lead wires then fit into the recess or groove provided for them in the top of the housing.

b. Install the generator field with the lead wires near the top. On installing the armature with the retainer assembled to it, turn the quarter circle between the two stop pins, downward, so that the stop screw, when inserted, permits about a one-quarter instead of a three-quarters turn of the generator field.

c. Install the armature shaft in the housing before replacing the front bearing dust seal. Then press the seal in against the outer race of the ball bearing.

d. Replace all rubber gaskets with new ones wherever possible. If the gasket between the housing and the cover is damaged, it should also be replaced.

e. On reassembling the seal, sleeve, and nut on the armature shaft, coat the gaskets thinly with grease and proceed as follows:

(*1*) Slip the small gasket into the nut.

(*2*) Slip the larger gasket into the sleeve.

(*3*) Slip the sleeve over the nut, from the threaded end.

(*4*) Slip the centering ring up against the end of the armature shaft.

(*5*) Screw the nut and sleeve assembly onto the shaft and tighten them.

f. On installing the carbon ring and the bellows seal, make sure that all the sealing surfaces are clean.

g. On installing the bellows seal, make sure that the fingers which rest against the folds of the bellows to keep them from vibrating are in place and have not slipped off one fold of the bellows.

h. To install the spring, retainer, and snap ring inside the bellows, place the spring in the bellows with the retainer over the exposed end. Make sure the end of the spring seats on the nose of the seal, and is not cocked or resting against the bellows. Press the retainer into the hole, compressing the spring. Tilt the snap ring, so that the part opposite the gap enters the bore of the retainer. At each side, where the ring protrudes, press the wire into the hole. The bore itself thus compresses the ring, as more and more of it is pressed in. Eventually it is fully compressed, and may be slid into place in its seating groove.

i. When the spinner motor and generator assembly has been fully installed in the reflector support, the generator field coil must be adjusted as described in paragraph 297.

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PART FOUR

MAINTENANCE PARTS LIST

SECTION I

MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B

356. INDEX.

357. INDEX TO MAJOR COMPONENT SYMBOLS.

ACCU—Control Unit BC-1094-C
ACR—Rectifier RA-70-A
AD—Auto-Dehydrator
AETU—Tracking Unit BC-1090-C
ARR—Power Supply Unit RA-132
ARU—Range Tracking Unit BC-1372
ATU—Tracking Unit BC-1086-C
CP—Indicator-Control Unit BC-1370
DP—Data Switch Panel PN-48
DU—Driver Unit BC-1080-C
DUA—Data Unit BC-1075-A
FS—Rectifier (Field) RA-71-A
LO—Oscillator BC-1374
M—Transmitter Frame Assembly BC-1373
OPS—Oscillator Phase Shifter
PA—Amplifier (Pre-IF) BC-1078-A
PCU—Control Unit BC-1085-C
PI—Indicator (Position) BC-1076-A
PPI—Indicator BC-1092-C
PPR—Rectifier (Plan Position) RA-69-A
PPU—Plan Position Unit BC-1058-C
R—Radio Receiver BC-1056-C
RaR—Rectifier (Range) RA-72-A
ReR—Rectifier (Receiver) RA-66-A
RI—Range Indicator BC-1371
RU—Range Unit BC-1062-C
RVA—Amplifier (Remote Video) BC-1074-A
SD—Servo Drive
TrL—Trailer Equipment including Line Regulator and Servo

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
		2C446-74A	AMPLIFIER BC-1074-A: (remote video).
		2C446-78A	AMPLIFIER BC-1078-A: (pre-IF).
		2C497A	ANTENNA, switching: box; BC-1132A.
		2Z288A-8	ANTENNA ASSEMBLY: IH Terpening #C-270-280; for transmission and reception of signals; p/o r-f line equip.
		3H3816/3	BEARING, exciter: Wemco dwg #M-7411001 part 9.
		3H3816/2	BEARING: motor and generator; Wemco dwg #M-7411001 part 3.
DUA	TB-60 TB-61	2Z9410.12	BLOCK, terminal: 10 cont; 6″ lg x 1-1/8″ wd x 1/2″; Jones #10-141.
TrL	BL-1976	3H388.1-4	BLOWER, air: electric; longitudinal type non-portable; unguarded; 1/6 hp; 115v; 60 cyc; 3 ph; 1,725 rpm; 13-5/8″ lg x 10-23/32″ wd x 11-17/32″ h; Corning Corp per Wemco dwg #P-77135910-1; Wemco dwg #T-7614134 part 18.
M	BL-202 BL-203	3H388.1-1	BLOWER, air: electric; 22 metal blades; non-portable; unguarded; powered by model J-49 motor 1/250 hp; 115v; 60 cyc; 3-3/4″ lg x 2-7/8″ wd x 2-15/16″ h; Eastern Air Devices Model J-54; Wemco dwg #T-7614134 part 16.
TrL	BL-1977	3H388.1-2	BLOWER, air: electric; longitudinal type; non-portable; unguarded; 1/6 hp; 1,725 rpm; 115v AC; 60 cyc; 3ph; 13-5/8″ lg x 10-23/32″ wd x 11-17/32″ h; Corning Corp per Wemco dwg #P-7713601, part 1; Wemco dwg #T-7614134, part 17.
M	B-201L	3H388-3	BLOWER, centrifugal: electric; 23 metal blades; nonportable; unguarded; capacitor-motor rated; 1/50 hp; 3,400 rpm; 60 cyc; single phase; 115v; 5-33/64″ wd x 5-3/16″ h; Eastern Air Devices Model #J-57.
DP	TB-17 thru TB-27	2Z9410.12	BOARD, terminal: 10 copper straps 3/4″ lg w/ two 6-32 screws in each; black cellulose acetate; over-all dimen 5-3/16″ lg x 1-1/8″ wd x 1/2″ thk; HB Jones cat #10-141; Wemco dwg #M-7408930, part 1.
TrL	TB-1976	3G1838-224.2	BOARD, terminal: rectangular plate; molded bakelite; 14-1/2″ lg x 4″ wd x 3/8″ thk; Wemco dwg #M-7416794 part G-1.
		3G1782	BOOK: film cut-out paper; Wemco dwg M-#7410443 part 1; Wemco dwg #T-7614136 part 137.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
PCU	E-1301 E-1351	2C680-1085B/B1	BRAKE, solenoid: relay; Rich-Allen #RA-1328-S; (coil #374, frame, armature, spring and stop same as for Leach Co. relay #1127BF; relay operated brakes for stopping gear on selsyn shaft; 115v; 60 cyc; 2 pole; over-all dimen 2-9/16″ x 1-1/2″ x 1-1/2″).
DP	S-1902 S-1903 S-1904	3H900-15-17	BREAKER, circuit: 3 PST; time delay; 15 amp; 250v AC; 125/250v DC; 6″ lg x 4-1/8″ wd x 3-25/64″ h; Wemco #999022; Collins #260N425.
DP	S-1901	3H900-100-13	BREAKER, circuit: magnetic; 3 poles; 250v AC; or 125v DC; 100 amp; bakelite; 9-3/10″ lg x 4-1/10″ wd x 4-7/10″ d; Wemco style #1222919-10.
		3H525-6	BRUSH, generator: carbon; spring; steel; cadmium-pl shunt spring; cadmium-pl 0.747″ wd x 0.247″ thk x 2-7/8″ lg; Stackpole Carbon Co; Wemco dwg #M-7411001, part 7.
RI PCU	B-901 B-902 B-1302	3H3100-3/B-5	BRUSH SET: carbon; GE, for GE motor model 5BN38HA10; 2 brushes per set.
M	T-201	3H550-2	BRUSH ASSEMBLY: for a voltage regulator; carbon; no finish; 1-1/8″ lg x 1/2″ wd x 1-1/2″ d over-all w/two 1-1/2″ pigtails; Superior Elec Co dwg #BP-1005GR-3; Wemco dwg #T-7614150 part 839.
		3H525-72	BRUSH, electrical cont: voltage regulator; morganite, black copper-pl 1-1/4″ lg x 11/16″ d x 0.192″ ±0.002″ thk over-all; Amer Transf #S-37245 part 2; Wemco #T-7614150 part 840.
		3H525-7	BRUSH, exciter: carbon, w/ cadmium-pl steel spring; copper shunt; cadmium-pl springs 0.247″ thk x 0.497″ wd x 2-1/2″ lg; Stackpole Carbon Co; Wemco dwg #M-7411001; Lima Works 4-D-8258 item 7.
		1B814.31	CABLE: #14; 2 cond; stranded 41/#30.
		1B3018-3	CABLE: rubber outer covering 0.41″ OD; GE cord X; 60% types; 3 cond; #18 AWG; 41 #34 AWG copper strands.
		1F425-5	CABLE: RG-5/u; #16 AWG single cond; small microwave cable; nominal impedance 51 ohms; bulk; stabilized polythyline with 2 shielded braids; Simplex Wire & Cable Co. RG-5/u.
		1B3018-11	CABLE: neoprene jacket; 0.735″ OD; GE type CW- 1267-A; 11 cond; #18 AWG copper; 41 #31 strands; CVS.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
		1B3002-5	CABLE, electrical, AF: Navy spec #15C1-MCOP-5; copper; 5 #2 AWG stranded cond; 26 strands of 0.010″ wire ea; 0.550″ OD; not color coded; rubber or synthetic resin shielding; rubber jacket; Gencable part #MCOP-5; Wemco dwg #T-7614153-967.
		1B3030-12	CABLE, electrical, AF: Navy spec #15C1-MCOP-12; copper; 12 cond; diam over impervious sheath 0.800″; 26 strands of wire 0.010″ diam; 0.800″ OD; rubber or synthetic resin shielding; halogenated rubber jacket; Wemco dwg #T-7614153-970.
		1B3002-2	CABLE: Navy spec #15C1-MCOP-2; copper; 2 cond #2 AWG stranded; 26 strands 0.010″ wire; 0.46″ OD; rubber insulated; rubber jacket; Gencable type #MCOP-2; Wemco dwg #T-7614153-973.
		1B3018-2.8	CABLE: rubber outer covering; 0.039″ OD; GE cord x 60% types; 2 cond; #18 AWG; 41 #34 AWG copper strand.
		1B818.31	CABLE: 4 cond; #18 stranded 42/#34.
		1B814.129	CABLE: interconnection; 41 strands #30 AWG single conductor; shielded; Whitney Blake #141202; plastic jacket; jacket 0.230″ diam; 1,600v from connections to ground testing.
		1B3020-1.2	CABLE: neoprene jacket; 0.500″ OD; GE type CW-1115A; single #20 AWG copper; 26 #34 AWG strands; low loss.
		1F425-11	CABLE: communication; RG-11/U 7 strands of #26 AWG wire; flexible; nominal impedance 75 ohms; bulk; stabilized polythyline; Amphenol #RG-11/U.
		1B3015-14	CABLE: neoprene jacket; 0.595″ OD; GE type CW-1273; 14 cond; #15 AWG; 32 #30 AWG strands; tinned copper.
		1B3020-4	CABLE: rubber sheath; 0.500″ OD; GE type MCS 4; Navy spec 15C1; 4 cond; #20 AWG; 16 #30 AWG strands.
		3E3158-48-8	CABLE ASSEMBLY, power: switchboard; no mutual binding; ea cable round cross sect OD 0.628″; 4 ft lg; 3 cables # 3 single conductor stranded 1331 #24; Wemco dwg #M-7417469; Wemco dwg #T-7614149 part #772.
		1F425-8	CABLE: RG-8/U; 7 strands #21 AWG wire; flexible; nominal impedance 52 ohms; bulk; stabilized polythylene; Amphenol #RG-8/U.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
		1B3015-22	CABLE: neoprene jacket; 0.595″ OD; GE type #CW-1273; 22 cond approx #15 AWG; 32 #20 AWG; 50 tinned copper.
		1B3015-10	CABLE: neoprene jacket; 0.595″ OD; GE type #CW-1273; 10 cond; #15 AWG; 32 #30AWG tinned copper; GR-S synthetic rubber.
		1B3015-7	CABLE: neoprene jacket; 0.595″ OD; GE type #CW1273A; 7 cond #15 AWG; 32 #20 AWG strands; tinned copper; GR-S synthetic.
		1B3020-7.1	CABLE: rubber outer covering; 0.580″ OD; GE type #MCS-7; Navy spec 15C1; 7 cond; #20 AWG; 16 #30 AWG strands; rubber insulated; copper braided shield.
		1B3014-3	CABLE: rubber covered; 0.56″ OD; GE type X; 3 cond; copper; #14 AWG; stranded; 84/0.0071″; 600v; 3/64 rubber insulation.
		2Z10008-82	CABLE ASSEMBLY, RF: coaxial; rigid "L"-section; characteristic impedance 51 ohms; single solid copper conductor 7/16″; Airline supported by 1/4″ wave length stubs; LH Terpening sections G-H dwg #0-270-220; Wemco dwg #DL-7502956, item 1.
		2Z10008-79	CABLE ASSEMBLY, RF: coaxial; rigid; characteristic impedance 51 ohms; single solid copper conductor 7/16″; air center cond stub supported; L.H. Terpening section F-G dwg #B-270-207; Wemco dwg #DL-7502956, item 1.
		1B802.5	CABLE, power: copper, tinned; single #2 AWG cond stranded; 259 #26 strands; 0.675″ OD; rubber insulation; rubber jacket; Gencable super service; Wemco dwg #T-7614153, part #985.
		2Z1587-284	CABLE CLAMP M-284: Army-Navy Aero; std AN-3057-6; (fits cable up to 1/2″; 15/16″ OD x 1-5/64″ lg x 1/2″ ID; thd 3/4″-20; #5-40 x 5/8″ screws; u/w but not p/o Plug PL-190.
		3H3816/1	CAP, generator brush-holder: black bakelite; 1-1/8″ x 3/8″ thk; Wemco Lima dwg 1-D-8660 item 6; Wemco dwg #M-7411001-P8.
		2Z1607-1	CAP ASSEMBLY, antenna vent: LH Terpening #A-270-268.
		3H683-7	CAP, exciter brush-holder: std black bakelite; 15/16″ diam x 3/8″ thk; Wemco dwg #7411001 part 2; Lima Works dwg #1-D-8660 item 5.
		2Z10009-16/1	CAP, weather: for section K-L; LH Terpening #A-270-298.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
ACCU	C-1408 C-1411	3DA8-18	CAPACITOR, fixed: paper; 8,000 mmf; +20% —10%; 1,000 vdcw; 7/16" x 1-9/16"; Sprague # PX-24B.
ATU	C-502	3DA10-118	CAPACITOR, fixed: mica; 10,000 mmf; ±5%; 500 vdcw; Aerovox type # 1467LS.
PPU	C-1611	3K4510311	CAPACITOR, fixed: mica; 10,000 mmf; ±10%; 600 vdcw; 1-5/8" lg x 1-1/8" wd x 23/64" thk; Aerovox Corp # 1445LS; ASA # CM45A103K; ASA spec # C75.3-1942.
PPU ARU	C-1618 C-2104 C-2105 C-2112 C-2119 C-2140 C-2143 thru C-2152 C-2159 C-2160	3DA10-208.2	CAPACITOR, fixed: paper; 10,000 mmf ±10%; 600 vdcw; Tobe # DP.
M RU R RaR OPS RVA PPU TrL ARR	C-212 C-603 C-614 C-616 C-623 C-630 C-640 C-641 C-650 C-656 thru C-659 C-734 C-810 C-952 C-960 C-963 C-1108 C-1602 C-1614 C-1620 C-1621 C-1635 C-1976 C-2205	3DA10-208.1	CAPACITOR, fixed: mica; 10,000 mmf; +20% —10%; 600 vdcw; Tobe type D; Wemco dwg # T-7614134, part 27.
ARU	C-2123 C-2128 C-2131 thru C-2136	3K4010321	CAPACITOR, fixed: mica; 10,000 mmf; ±10%; 300 vdcw; 1-1/32" lg x 41/64" wd x 11/32" thk; ASA # CM40B103K.
RI	C-904	3BA10-155	CAPACITOR, fixed: mica; 10,000 mmf; ±10%; 2,500 vdcw; 1-3/4" lg x 1-5/16" wd x 3/4" thk; Aerovox Corp Type # 1652LS; CD# 95-51010.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
RU R	C-608 C-612 C-729	3D9005-42	CAPACITOR, fixed: ceramic, 5 mmf; ±10%; 500v dcw; 7/32″ diam x 7/16″ lg; Erie # NPOK5.
OPS ACCU ARU	C-957 C-1412 C-2117	3D254	CAPACITOR, variable: air; 7.5 to 99 mmf; Teleradio Eng (same as Hammarlund KS-7878 except has shaft lock; marking "KS-7878" shall be omitted).
OPS	C-962	3D9005VE4	CAPACITOR, fixed: insinal dielectric; 4 sect; approx 8 mmf; Wemco dwg # M-7414822, part 1.
RU	C-606	3D9010V-8	CAPACITOR, variable: ceramic; 10 to 110 mmf; 500 vdcw; 1-57/64″ x 1-1/4″ x 27/64″ thk; Erie # N500-TS5D.
RVA	C-1107	3D9010-24	CAPACITOR, fixed: mica; 10 mmf; ±2.5%; 500 vdcw; 9/16″ lg x 1/8″ wd x 9/16″ thk; Erie type # N300A10 ±2.5%; Wemco dwg # T-7614135, part 81.
RU	C-637 C-651	3D9010-16	CAPACITOR, fixed: mica; 10 mmf; ±10%; 500 vdcw; Aerovox # 1468LS.
DU R	C-102 C-723	3D9010-24	CAPACITOR, fixed: ceramic; 10 mmf; ±10%; 500 vdcw; Erie type NPO, style K.
M	C-208	3D9010V-35	CAPACITOR, variable: air; 10 mmf; 4,000 vdcw; 1-7/8″ lg x 1-3/4″ wd x 2-5/8″ h; shaft 5/16″ diam, 1-5/8″ lg; Hammarlund part # N-10; Wemco dwg # M-7408811, part 1.
RU	C-633	3D9020-9.1	CAPACITOR, fixed: mica; 20 mmf; ±10%; 500 vdcw; 3/4″ lg x 7/16″ wd x 3/16″ thk; Aerovox Corp type # 1468LS.
DU RU	C-101 C-604 C-642	3D9020-5.1	CAPACITOR, fixed: ceramic; 20 mmf; ±10%; zero temp coeff; 500 vdcw; 11/16″ lg x 7/32″ diam; Erie # NPOL-15.
ARU	C-2124	3K2524022	CAPACITOR, fixed: mica; 24 mmf; ±5%; 500 vdcw; 1-1/16″ x 15/32″ wd x 7/32″ thk x 15/32″ h; AWS # CM25B240J.
ARU	C-2102	3K2539021	CAPACITOR, fixed: mica; 39 mmf; ±10%; 500 vdcw; Aerovox; CM25B39CK.
DU	C-106	3D9040-12.2	CAPACITOR, fixed: ceramic; 40 mmf; ±10%; 500 vdcw; 1-9/64″ lg x 5/16″ diam; Erie # NPON.
OPS	C-964	3K2047032	CAPACITOR, fixed: mica; silver-coated; 46 mmf; ±5%; 500 vdcw; 45/64″ lg x 29/64″ wd x 3/16″ thk; Aerovox 1A69; Wemco dwg # T-7614134, part 21.
RU	C-638 C-639	3D9050-10	CAPACITOR, fixed: mica; 50 mmf; ±10%; 500 vdcw; 1,000 vdct; Aerovox Corp type 1468LS; CD # 5WLS.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
M RU	C-209 C-646 C-654	3D9050-79.1	CAPACITOR, fixed: ceramic; 50 mmf; ±10%; 500 vdcw; Erie #NPOM.
PPU	C-1613	3D9050-87.1	CAPACITOR, fixed: ceramic; 50 mmf; ±10%; 500 vdcw; 11/16″ lg x 7/32″ diam; Erie type L.
ARU	C-2109 C-2110 C-2118	3K2551022	CAPACITOR, fixed: mica; 51 mmf; ±5%; 500 vdcw; 1-1/16″ ±3/64″ wd x 7/32″ thk x 15/32″ h; AWS #CM25B510K.
RU	C-655	3D9070-12	CAPACITOR, fixed: mica; 70 mmf; ±10%; 500 vdcw; Aerovox type #1468LS.
ACCU	C-1422	3K2075012	CAPACITOR, fixed: mica; 75 mmf; ±5%; 500 vdcw; 51/64″ lg x 15/32″ wd x 7/32″ thk; ASA #CM20A750J; ASA spec JAN-C-5.
RU R RVA PPU PA	C-607 C-624 C-653 C-663 C-704 C-708 C-712 C-716 C-722 C-746 C-1105 C-1638 C-1857	3K2010121	CAPACITOR, fixed: mica; 100 mmf; ±10%; 500 vdcw; 51/64″ lg x 15/32″ wd x 7/32″ thk; ASA CM20B101K; ASA spec C75.3-1942; Aerovox type #1468LS.
ARU	C-2164	3K2510121	CAPACITOR, fixed: mica; 100 mmf; ±10%; 500 vdcw; Aerovox type CM25B101K; Wemco dwg #T-7614136, part 125.
DU	C-118 C-119 C-120 C-121	3D9100-127	CAPACITOR, fixed: mica; 100 mmf; ±5%; 1,250 vdcw; 2-1/8″ lg x 1-1/8″ wd x 11/32″ thk; Aerovox part #1446LS; Wemco dwg #T-7614134, part 44.
RU	C-644 C-648	3K2015121	CAPACITOR, fixed: mica; 150 mmf; ±10%; 500 vdcw; 51/64″ lg x 15/32″ wd x 7/32″ thk; Aerovox type #1468LS; ASA #CM20B151K; ASA spec #C75.3-1942.
OPS	C-953	3D9175-10	CAPACITOR, fixed: ceramic; 175 mmf; ±5%; 500 vdcw; 1.300″ lg x 0.340″ diam; Centralab class B; Wemco dwg #T-7614134, part 22.
OPS	C-958 C-959	3N2020132	CAPACITOR, fixed: silver mica; 200 mmf; ±5%; 500 vdcw; 51/64″ lg x 15/32″ wd x 7/32″ thk; Aerovox type #1469 LST; ASA #CM20C201J; ASA spec #C75.3-1942.
DU	C-122 C-123	3D9200-33.3	CAPACITOR, fixed: mica; 200 mmf; ±10%; 2,500 vdcw; Aerovox #1447 LS.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
R	C-715	3D9250-9	CAPACITOR, fixed: mica; 250 mmf; ±10%; 500 vdcw; 1,000 vdct; Aerovox type #1468LS.
RU PPU	C-635 C-647 C-661 C-1612	3D9500-10	CAPACITOR, fixed: mica; 500 mmf; ±5%; 500 vdcw; 45/64″ lg x 29/64″ wd x 3/16″ thk; Aerovox type #1468LS; Wemco dwg #T-7614135 part 57.
RU	C-602 C-605	3D9500-89	CAPACITOR, fixed: ceramic; 500 mmf; ±10%; 500 vdcw; 1-1/16″ lg x 17/64″ diam; Erie #N750D.
ACCU	C-1405	3K2051112	CAPACITOR, fixed: mica; 510 mmf; ±5%; 500 vdcw; 51/64″ lg x 15/32″ wd x 7/32″ thk; ASA #CM20A511J; spec JAN-C-5.
M	C-211	3DA1.600V-1	CAPACITOR, variable: clear India ruby mica; 600 mmf to 1,600 mmf; 11/32″ lg x 7/8″ wd x 1-1/8″ h; shaft 5/16″ diam; 11.16″ lg; shaft bushing 21/32″ lg; Meissner per Wemco dwg #M-7408898, part 1.
ARU	C-2103 C-2153 C-2154	3K3010222	CAPACITOR, fixed: mica; 1,000 mmf; ±5%; 500 vdcw; 53/64″ lg 53/64″ wd x 9/32″ thk; ASA #CM30B102J; ASA spec #C75.3-1942.
PPU	C-1615	3K3010231	CAPACITOR, fixed: silver mica; 1,000 mmf; ±10%; 500 vdcw; Aerovox #1464LS.
M R RVA PPU	C-210 C-701 C-703 C-705 C-707 C-709 C-711 C-713 C-717 C-718 C-719 C-720 C-731 C-732 C-733 C-737 C-739 C-741 C-742 C-744 C-745 C-747 C-748 C-1101 C-1103 C-1104 C-1117 C-1607 C-1619 C-1622	3K3010211	CAPACITOR, fixed: mica; 1,000 mmf; ±10%; 500 vdcw; 53/64″ lg x 53/64″ wd x 9/32″ thk; Aerovox type #1467LS; ASA #CM30A102K; ASA spec #C75.3-1942.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
	C-1623 C-1633 C-1634		
PA	C-1851 C-1852 C-1853 C-1854 C-1856 C-1858 C-1859 C-1861 C-1862 C-1863 C-1864		
RI	C-905 C-918 C-919	3K5510221	CAPACITOR, fixed: mica; 1,000 mmf; ±10%; 2,500 vdcw; 1-25/32″ lg x 1-11/32″ thk. Aerovox type #1652LS; ASA CM55B102K; ASA spec #C75.3-1942.
ARU	C-2101	3K3012221	CAPACITOR, fixed: mica; 1,200 mmf; ±10%; 500 vdcw; 53/64″ lg x 9/32″ thk x 53/64″ wd; ASA #CM30B122K.
RU	C-611	3KDA1.500-20	CAPACITOR, fixed: mica; 1,500 mmf; ±10%; 500 vdcw; 25/32″ lg x 25/32″ wd x 9/32″ thk; Aerovox #1467LS.
ACCU	C-1423	3K3015214	CAPACITOR, fixed: mica, 1,500 mmf; ±20%; 500 vdcw; 53/64″ lg x 53/64″ wd x 9/32″ thk; ASA #CM30A152M; spec #JAN-C-5.
RU	C-609	3DA2-70	CAPACITOR, fixed: mica; 2,000 mmf; ±10%; 500 vdcw; Aerovox type #1467LS; Solar type MWW-1233-10.
RVA PPR PPU	C-1109 C-1509 C-1626 C-1628 C-1631 C-1632	3DA2-141	CAPACITOR, fixed: paper; 2,000 mmf; +20% —10%; 600 vdcw; 53/64″ lg x 53/64″ wd x 11/32″ thk; Tobe style D.
DU R OPS PPU	C-103 C-104 C-725 C-954 C-961 C-1637	3DKA3-61	CAPACITOR, fixed: mica; 3,000 mmf; ±10%; 500 vdcw; 25/32″ lg x 25/32″ wd x 9/32″ thk; Aerovox #1467LS; RCA #P-720473-41.
DU	C-105	3DA3-57.1	CAPACITOR, fixed: mica; 3,000 mmf; ±10%; 1,250 vdcw; Aerovox type #1446LS.
ACR	C-1460	3DA3-34	CAPACITOR, fixed: paper; 3,000 mmf; ±20%; 800 vdcw; 13/16″ x 13/16″ x 19/64″ thk; Wemco #404B.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
ARU	C-2141 C-2142	3K3533221	CAPACITOR, fixed: mica; 3,300 mmf; ±10%; 500 vdcw; 53/64″ lg x 53/64″ wd x 11/32″ thk; ASA # CM35B332K; ASA spec # 75.3-1942.
SD	C-926 C-927	3DA5-22.1	CAPACITOR, fixed: India mica; 5,000 mmf; ±20%; 500 vdcw; 3/4″ x 3/4″ x 1/4″; Cornell-Dubilier # 1; Wemco dwg # T-7614135, part 97.
PPU	C-1603 C-1608 C-1625 C-1627 C-1629 C-1630	3DA5-143	CAPACITOR, fixed: paper; 5,000 mmf; +20% —10%; 600 vdcw; 53/64″ lg x 53/64″ wd x 11/32″ thk; Tobe style D.
ARU	C-2107	3K3551221	CAPACITOR, fixed: mica; 5,100 mmf; ±10%; 500 vdcw; 53/64″ wd x 11/32″ thk x 53/64″ h; AWS # CM35B512K; Aerovox # 1467L.
ARU	C-2139	3K3556224	CAPACITOR, fixed: mica; 5,600 mmf; ±20%; 500 vdcw; 53/64″ wd x 11/32″ thk x 53/64″ h; AWS # CM35B562M; Aerovox; Wemco dwg # T-7614136, part 121.
RU	C-613 C-649	3DA6-15.1	CAPACITOR, fixed: mica; 6,000 mmf; ±10%; 300 vdcw; 25/32″ lg x 25/32″ wd x 9/32″ thk; Aerovox # 1467LS.
ARU	C-2121	3K3568221	CAPACITOR, fixed: mica; 6,800 mmf; ±10%; 500 vdcw; 53/64″ lg x 53/64″ wd x 11/32″ thk; ASA # CM35B682K; Wemco dwg # T-7614136, part 115.
ACCU	C-1401 C-1402	3DA8-19	CAPACITOR, fixed: silver mica; 8,000 mmf; ±1%; 500 vdcw; 8/32″ x 1-1/8″ x 1-7/8″; Wemco type # 402-C.
ACCU	C-1406 C-1416	3DA15-21	CAPACITOR, fixed: paper; 15,000 mmf; +20% —10%; 1,000 vdcw; 1-7/16″ lg x 9/16″ diam; Sprague PX24B.
ARU	C-2106 C-2129	3DA50-173	CAPACITOR, fixed: oil-filled; paper; 50,000 mmf; +20% —10%; 600 vdcw; 1-3/4″ wd x 9/16″ thk x 1″ h; Solar # XEMRBW6-.05; Wemco dwg # T-7614136, part 108.
RVA	C-1113	3DA50-39	CAPACITOR, fixed: paper; 50,000 mmf; +20% —10%; 600 vdcw; 1-13/16″ lg x 1″ wd x 3/4″ h; CD # DYR-6005.
RVA	C-1116	3DA50-175	CAPACITOR, fixed: paper; 50,000 mmf; ±10%; 1,000 vdcw; 2-5/16″ lg x 3/4″ wd x 1-5/16″ C-D type PC-2082; Wemco dwg # T-7614135, part 84.
		3DA100-425	CAPACITOR, fixed: paper; 1 section; 100,000 mmf; ±10%; 400 vdcw; metal can approx 1-1/8″ x 1-1/2″ wd; flex term 1-1/2″ lg; Wemco Lima wks dwg # 8-D-2530IT1; Wemco # M-7411001 P-10.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
ARU	C-2122	3DKA100-119.1	CAPACITOR, fixed: paper; 100,000 mmf; +20% —10%; 400 vdcw; 1" h x 1-3/4" wd x 9/16" thk; Solar #XEMRB4-1.
AETU	C-402	3DA100-438	CAPACITOR, fixed: paper; 100,000 mmf; ±10%; 500 vdcw; 2-1/4" lg x 7/16" wd; CD #PC-2080; Wemco dwg #T-7614134, part 33.
	C-452		
RU	C-634		
	C-636		
	C-643		
	C-645		
	C-652		
R	C-724		
	C-726		
	C-727		
	C-738		
	C-740		
SD	C-928		
RVA	C-1110		
	C-1118		
PPU	C-1605		
	C-1606		
	C-1636		
AETU	C-401	3DA100-210.1	CAPACITOR, fixed: paper; 100,000 mmf; ±10%; 500 vdcw; Dubilier type PC-2079.
	C-451		
R	C-749		
PPR	C-1507		
OPS	C-956	3DKA100-200	CAPACITOR, fixed: paper; 100,000 mmf; ±10%; 600 vdcw; 1-1/16" h x 1.812" wd x 1/2" thk; Aerovox #618T.
TrL	C-1977	3DA100-435	CAPACITOR, fixed: paper; single sect; 100,000 mmf; ±10%; 600 vdcw; 1-3/4" x 1" x 3/4"; Aerovox #630; Wemco dwg T-7614134, part 23.
RI	C-901	3DA100-351	CAPACITOR, fixed: paper; 100,000 mmf; ±10%; 600 vdcw; 1-3/4" x 1" x 3/4"; Aerovox #630-B.
	C-902		
	C-903		
RU	C-660	3DA100-432	CAPACITOR, fixed: paper; 100,000 mmf; ±10% —3%; 600 vdcw; 2-1/2" lg x 1-11/16" ±1/16" wd x 3/4" thk; Aerovox type #630; Wemco dwg #T-7614135, part 75.
RaR	C-809		
ARR	C-2204		
ARU	C-2108	3DA100-192	CAPACITOR, fixed: paper; 100,000 mmf; +20% —10%; 600 vdcw; 1-3/4" x 1" x 9/16"; Solar #XEMRB6-0.1.
	C-2111		
	C-2116		
	C-2157		
	C-2158		
ACCU	C-1419	3DA100-254	CAPACITOR, fixed: paper; 100,000 mmf; +20% —10%; 600 vdcw; 1-1/2" x 11/16" x 2-1/2"; Tobe #OM-610-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
ARU	C-2114 C-2130	3DA100-434	CAPACITOR, fixed: paper; dual; 100,000 mmf; +20% —10%; 600 vdcw; 1-1/2" h x 1-3/4" wd x 9/16" thk; Solar #2XEMRBW6-.1; Wemco dwg #T-7614136, part 13.
ACR	C-1457	3DA100-253	CAPACITOR, fixed: paper; 100,000 mmf; +20% —10%; 1,000 vdcw; 2-1/2" x 1-1/2" x 11/16" thk; Tobe #CM-1010-B.
RaR	C-808	3DA100-433	CAPACITOR, fixed: paper; 100,000 mmf; +20% —10%; 3,000 vdcw; Aerovox type 3009MS.
PPR	C-1505 C-1506	3DA100-228	CAPACITOR, fixed: paper; 100,000 mmf; ±10%; 7,500 vdcw; 3-3/4" x 3-1/2"; GE #26F439; Wemco dwg #M-7408519, part 1.
M	C-205	3DA125	CAPACITOR, fixed: paper; 125,000 mmf; ±15%; 27,000 vdcw; 8-1/8" x 7-1/16"; Wemco dwg #M-7408812, part 1.
ACCU	C-1421	3DA200-22	CAPACITOR, fixed: paper; 200,000 mmf; +20% —10%; 600 vdcw; 2" x 1-3/16" x 11/16" thk; Tobe #OM-620-B.
ACR	C-1461	3DA200-23	CAPACITOR, fixed: paper, 200,000 mmf; +20% —10%; 1,000 vdcw; 2" h x 1-3/16" wd x 11/16" thk; Tobe #OM-1020-B.
ARU	C-2113	3DKA250-62	CAPACITOR, fixed: paper; 250,000 mmf; +20% —10%; 400 vdcw; 1-1/2" h x 2-7/16" wd x 9/16" d; Solar #XEMBR4-.25.
RVA	C-1112	3DA250-13	CAPACITOR, fixed: 250,000 mmf; ±10%; 600 vdcw; CD #DYR-6025.
ACCU	C-1403 C-1404 C-1410	3DA250-114	CAPACITOR, fixed: paper; 250,000 mmf; +20% —10%; 600 vdcw; 1-1/2" x 11/16" x 2-1/2"; Tobe #OM-625-B.
RVA	C-1120	3DA250-102	CAPACITOR, fixed: paper; 250,000 mmf; ±10%; 1,000 vdcw; Dubilier type #PC-2084.
ACCU ACR	C-1418 C-1420 C-1459	3DA250-157	CAPACITOR, fixed: paper; 250,000 mmf; +20% —10%; 1,000 vdcw; 1-13/16" lg x 1" wd x 13/16" h; Tobe #RLO-1025.
ARU	C-2115 C-2120	3DA250-154	CAPACITOR, fixed: oil-filled; paper; 250,000 mmf; +20% —10%; 1,000 vdcw; 2-7/16" wd x 9/16" thk x 1-7/8 h; Solar #XEMRBW10-.25.
DU M	C-107 C-206	3DA250-213	CAPACITOR, fixed: paper; 250,000 mmf; ±10%; 1,000 vdcw; 2-1/4" x 2" h x 5/8"; Cornell-Dubilier Elec type PC-2083; Wemco dwg #T-7614134, part 41.
SD	C-931 C-932	3DA500-262	CAPACITOR, fixed: oil-filled; paper; 2 sect; 500,000 mmf; +20% —10% per sect; 400 vdcw; 1-3/4" wd x 9/16" thk x 2-1/2" h; Solar #2XEMRBW4-.5; Wemco dwg #T-7614135, part 99.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
R	C-721	3DA500-153.1	CAPACITOR, fixed: paper; 500,000 mmf; ±10%; 500 vdcw; Dubilier type PC-2075.
AETU R RVA	C-406 C-456 C-728 C-1111	3DA500-325	CAPACITOR, fixed: paper; 500,000 mmf; ±10%; 500 vdcw; 2-3/8″ lg x 3/4″ wd x 1-9/16″ h; Cornell-Dubilier Elec type PC-2076; Wemco dwg #T-7614134, part 35.
DU	C-110	3DA500-324	CAPACITOR, fixed: paper; 500,000 mmf; ±10%; 500 vdcw; 4-7/8″ lg x 2-1/4″ wd x 6-1/4″ thk; (similar to Aerovox type 5009 except series inductance to be kept to a minimum approx 0.1 mh); Wemco dwg #T-7614134, part 42.
		3DA500-30	CAPACITOR, fixed: oil-filled; paper; type DYR; 1 sect; 500,000 mmf; ±10%; 600 vdcw; metal can; 1-7/8″ x 2-1/2″ x 7/8″ thk; Wemco Lima dwg 8-D-2601, item 1; Wemco dwg #M-7411001, part 11.
ACCU ACR	C-1413 C-1417 C-1455 C-1456	3DA500-186	CAPACITOR, fixed: paper; 500,000 mmf; +20% —10%; 600 vdcw; 2-1/2″ h x 1-1/2″ wd x 11/16″ d; Tobe #OM-650-B.
SD	C-930	3DA500-141	CAPACITOR, fixed: paper; 500,000 mmf; +20% —10%; 600 vdcw; 2-1/16″ h x 11/16″ x 1-5/16″ lg; Solar #XRMRB6-0.5.
RVA	C-1115	3DA500-30	CAPACITOR, fixed: paper; 500,000 mmf; 600 vdcw; 2-9/16″ x 1-3/8″ x 7/8″; terminals are to be side lugs which are oriented to point upward; Dubilier type DYR-6050.
ACCU	C-1458	3DA500-188	CAPACITOR, fixed: paper; 500,000 mmf; +20% —10%; 1,000 vdcw; 2-1/2″ h x 1-1/2″ wd x 11/16″ thk; Tobe Deutschmann OM-1050-B.
LO	C-1806	3DA800-5	CAPACITOR, fixed: paper; 800,000 mmf; to 850,000 mmf; 220v AC; 1-1/16″ OD x 2-1/4″ lg; Dubilier type VC-1163-A; Wemco dwg #T-7614134, part 48.
AETU ATU	C-404 C-454 C-503 C-504 C-509 C-510	3DB1.609-1	CAPACITOR, fixed: paper; 1 mf; +10% —3%; 600 vdcw; 1-13/16″ lg x 1-1/16″ wd x 2-1/8″ h; Aerovox #609MS.
DU M RU RaR OPS	C-111 C-113 C-214 C-215 C-662 C-806 C-807 C-955	3DB1.2077	CAPACITOR, fixed: paper; 1 mf; ±10%; 500 vdcw; Dubilier type #PC-2077.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
RU	C-615	3DB1.2078	CAPACITOR, fixed: paper; 1 mf; ±10%; 500 vdcw; Dubilier type # PC-2078.
	C-631		
	C-632		
R	C-735		
	C-736		
	C-743		
RVA	C-1119		
PPU	C-1601		
SD	C-933	3DB1.46	CAPACITOR, fixed: paper; 1 mf; +20% —10%; 600 vdcw; 2-5/16″ lg x 11/16″ wd x 2-9/16″ h; Solar # XKMRBW6-1; metal case hermetically sealed; mineral oil impregnated.
ACCU	C-1407	3DB1.601-2	CAPACITOR, fixed: paper; 1mf; +20% —10%; 600 vdcw; 1-1/2″ x 11/16″ x 2-1/2″; Tobe # OM-601-B.
	C-1409		
	C-1414		
	C-1415		
ACR	C-1454		
ARU	C-2125	3DB1.14	CAPACITOR, fixed: paper; 1 mf; +20% —10%; 600 vdcw; 1-3/4″ x 2-1/2″ x 9/16″; Solar # XEMRBW6-1.
	C-2126		
	C-2127		
	C-2155		
	C-2156		
	C-2161		
	C-2162		
	C-2163		
ARU	C-2137	3DB1.47	CAPACITOR, fixed: oil-filled; paper; 1 mf; +20% —10%; 600 vdcw; 1-3/4″ wd x 1″ thk x 2-1/8″ h; Solar # XLMJW6-1.
	C-2138		
PPU	C-1610	3DB2-18	CAPACITOR, fixed: paper; 2 mf; +10% —3%; 600 vdcw; 1-3/4″ lg x 1″ wd x 2-3/4″ h; Aerovox type 609MS.
	C-1617		
	C-1624		
CP	C-1751		
LO	C-1805	3DB2.1009-2	CAPACITOR, fixed: paper; 2 mf; ±10%; 1,000 vdcw; 3-7/8″ h x 1-13/16″ lg x 1-1/16″ thk; Aerovox # 1009MS.
M	C-204	3DB2-18	CAPACITOR, fixed: paper; 2 mf; +10% —3%; 2,000 vdcw; 4″ x 3-3/4″ x 1-1/4″; Aerovox type # 2009MS.
	C-207		
RaR	C-805		
M	C-203	3DB2-17	CAPACITOR, fixed: paper; 2 mf; ±10%; 5,000 vdcw; 3-7/8″ x 4-9/16″ x 3-7/8″; Aerovox type # 5009MS.
M	C-201	3DB2.50FP	CAPACITOR, fixed: inertex dielectric paper; 2 mf; ±10%; 12,500 vdcw; 4-1/8″ thk x 13-1/4″ wd x 9-1/4″ h; Wemco type # FP-50; style # 1310585.
	C-202		
PCU	C-1301	3DB3.609	CAPACITOR, fixed: paper; 3 mf; 600 vdcw; Aerovox type # 609MS; 2-3/4″ lg x 1-1/16″ wd x 4-3/4″ thk; Wemco dwg # T-7614135, part 61.
	C-1351		

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
M	C-213	3DB3E75	CAPACITOR, fixed: paper; 3.75 mf; ±10%; 330 vdcw; 4-1/16" x 1-1/4" x 2-1/2" over-all GE cat #21F218.
DU	C-108 C-112 C-114 C-115 C-116	3DB4-190	CAPACITOR, fixed: paper; 4 mf; ±10%; 600 vdcw; 4-1/2" h x 3-5/8" lg x 1-3/16" wd; Aerovox type 609-MS; Wemco dwg #T-7614134, part 25.
AETU	C-403 C-405 C-453 C-455		
ATU	C-501		
RaR	C-801 C-802 C-803		
ReR	C-1001 C-1002		
PPR	C-1501 thru C-1504		
LO	C-1801 thru C-1804		
ARR	C-2202 C-2203		
M	C-216	3DB4-153	CAPACITOR, fixed: paper; 4 mf; ±10%; 600 vdcw; 3-1/8" lg x 3" wd x 3-1/2" diam; Wemco dwg #7614136P-124.
DU ARR	C-117 C-2201	3DB4-155	CAPACITOR, fixed: paper; oil dielectric; 4 mf; ±10%; 1,000 vdcw; 4-5/8" h x 2-1/2" wd x 1-3/16" thk; Aerovox #1009MS.
TrL	C-1976	3DB5-2	CAPACITOR, fixed: paper; 5 mf; ±5%; 330 vacw; CD #KG-3050.
ACR	C-1451 C-1452 C-1453	3DB8-61.2	CAPACITOR, fixed: paper; 8 mf; +20% —10%; 1,000 vdcw; 4-3/4" h x 3-3/4" lg x 1-1/4" wd; CD #T-10080.
ATU	C-505 thru C-508	3DB10-20	CAPACITOR, fixed: paper; 10 mf; ±10%; 600 vdcw; Aerovox type #D609MS.
ReR	C-1003 C-1004		
RVA	C-1114		
ARR	C-2206 C-2207		
		2Z2636-37	CLAMP: Amphenol #AN-3057-24; aluminum 1-9/16" lg x 2-3/16" diam over-all; for max cable diam of 1-9/16"; fits AN type shell 36; one end is threaded inside 2"–18; other end has two 1/4"–20 x 1-1/4" clamping screws; u/w Test Set AN/TPM-1.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
		2Z2636-3	CLAMP M-293: Amphenol #AN-3057-12; (split cable clamp w/coupling ring; takes cable size 7/8″ max; 5/16″ min; metal shell 1-3/8″ diam x 1-3/16″ lg coupling ring thd 1-3/16″–18; two clamp screws 8-32 x 7/8″).
		2Z2601-3	CLAMP, cable: AN-3057-12-6; die cast aluminum; fine grain metallic sand blast; satin; nonreflecting surface; two bolts; fits cables 3/16″ to 1/2″ diam OD 1-3/16″ x 1-1/8″ Am pheno AN-3057-12-6; max OD cable 1/2″.
		2Z2636-287	CLAMP, cable: AN-3057-10-6; cast aluminum; finish fine grain metallic sand blast satin; nonreflecting surface; two bolts; over-all dimen 1-3/16″ diam x 1-1/8″ lg w/fitting 15/32″ to 3/16″ size; Am phenol AN-3057-10-6; fits 1/2″ cable (max OD).
		2Z2601-5	CLAMP, cable: AN-3057-8-3; die cast aluminum; finish, fine grain metallic sand blast; nonreflecting surface; two bolts; over-all dimen 1-1/16″ diam x 1-1/8″ lg w/fitting 1/4″ x 1/8″; Am phenol #AN-3057-8-3; fits size 3/16″ cable (max OD).
		2Z2601-6	CLAMP, cable: AN-3057-16-12; die cast aluminum; finish, fine grain metallic sand blast; nonreflecting surface; two bolts; over-all dimen 1-5/8″ diam x 1-5/16″ lg w/fitting 13/16″ x 9/16″ Am phenol AN-3057-16-12; fits size 7/8″ cable (max OD).
		2Z2601-7	CLAMP, cable: AN-3057-16-10; die cast aluminum; finish, fine grain metallic sand blast; nonreflecting surface; two bolts; over-all dimen 1-5/8″ diam x 1-5/16″ lg w/ fitting 11/16″ x 9/32″; Am phenol AN-3057-16-10; fits size 11/16″ cable (max OD).
		2Z2601-9	CLAMP, cable: AN-3057-6-3; die cast aluminum; finish, fine grain metallic sand blast; nonreflecting; two bolts; over-all dimen 15/16″ diam x 1-5/64″ lg w/fitting 1/4″ x 1/8″; Am phenol AN-3057-6-3; fits size 3/16″ cable (max OD).
	RI X-901A X-902A	2Z7857-14	CLAMP, tube base: 1/16″ CRS; cadmium-pl; four bolts; 3-3/32″ OD, mtg/c on 2.75″ rad, 0.182″ thk; Cinch type #8593; Wemco dwg #7811322, part 1.
		2Z2636-2	CLAMP: Am phenol #AN-3057-16.
		2Z2635.131	CLAMP, selsyn: 15/32″ wd x 15/32″ lg x 5/32″ thk; hole through center 7/32″ diam; Palmer-Bee Co; PC 208-201-C; Wemco dwg #7417540, part 4.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
		2Z2635.133	CLAMP, selsyn: steel; 7/8″ lg x 5/8″ wd x 3/16″ thk; 1/32″ flange cut 1/32″; 11/32″ ID; Palmer-Bee Co RI 108-026-C; Wemco dwg #M-7417540, part 2.
		2Z2635.134	CLAMP, selsyn: steel; 9/16″ diam x 1/4″ over-all thk; 3/32″ flange cut 3/32″; hole through center 3/16″; 3/8″ flange diam; Palmer-Bee Co; PI 307-445-C; Wemco dwg #M-7417540, part 38.
		2Z2635.132	CLAMP, selsyn: steel; 3/8″ wd x 1/2″ lg x 1/4″ thk; 1/8″ flange cut 1/8″; hole through center 1/4″ ID; countersunk 5/16″; Palmer-Bee Co; RI 108-045-C; Wemco dwg #M-7417540, part 3.
M	Z-202	3Z1891-37.1	CLEANER, air: Wemco #7416052-G1.
M	Z-201	3Z1891-37	CLEANER, air: Wemco #741607-3G1.
		6Z3856-2/1	CLEANER, air: fiber glass; 10″ x 20″ x 1″.
		2Z3806.3	CLEANER, air: spun glass filter cloth, fine and coarse; 1-1/8″ diam, 3/16″ thk; dielectric part/dwg AD-17-2 & 3; Wemco dwg #7416899, part 4.
M		2Z2712	CLIP, tube cont: brass nickel-pl; 5/16″ x 5/16″ x 3/4″; National Co #12; Wemco dwg #7614152, part 904.
LO PPR RaR		2Z3018-15	CLIP, tube cont: 1-1/8″ lg x 9/16″ h; James Millen #36002.
DU		2Z2712.30	CLIP, tube cont: phosphor bronze; 1-1/2″ x 3/8″ x 3/32″; American Brass Co cat. #A878; Wemco dwg #7408633, group 1, part 901.
		6Z1973	CLOCK, program: dielectric dwg #AD-26-2.
ARU	L-2105 L-2106 L-2107	2C6996-1372/2	COIL, radio, video: pulse delay line; single layer wound; shielded; characteristic impedance 400 ohms for 0.7 microsecond pulse delay line; Wemco dwg #7714043-G1.
ARU	L-2102	3C332-455	COIL, radio, RF: choke integral type; 4 pie universal winding; unshielded; 50 turns #34 wire; 125 uh ±10%; Wemco pt/dwg #7415455-G1.
ARU	L-2101	3C332-455-1	COIL, radio, RF: choke; integral type; 4 pie universal wound; unshielded; 25 turns #34 ga wire; 25 uh +20% —5%; Wemco dwg #7415455-G2.
RVA	L-1102	2C446-74A/C1	COIL, RF: IF tuning; brass core; adjustable; unshielded; 13 turns #26 wire; Wemco dwg #M-7408511-G5.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
R	L-708	2C5056A/C4	COIL, radio, RF: IF tuning; adjustable brass core; not plug-in; unshielded; approx 2″ lg x 11/16″ wd; coil is 26 turns of # 26 wire; Wemco dwg # M-7408511-G7.
R	L-706	2C5056A/C3	COIL, radio, RF: IF tuning; adjustable brass core; not plug-in; unshielded; approx 2″ lg x 11/16″ wd; mts by hex nuts on adjustable core; coil form is molded bakelite; 2 solder lug term; coil is 14 turns of # 26 wire; 22″ of wire; Wemco dwg # M-7408511-G6.
R	L-704	2C5056A/C1	COIL, radio, RF: IF tuning; adjustable brass core; not plug-in; unshielded; approx 2″ lg x 11/16″ wd; mts by hex nuts on adjustable core; core form is molded bakelite; 2 solder lug term; coil is 9 turns of # 26 wire; 15″ of wire; Wemco dwg # M-7408511-G1.
R PA	L-702 L-1853	2C5056A/C2	COIL, radio, RF: IF tuning; adjustable brass core; not plug-in; unshielded; approx 2″ lg x 11/16″ wd; mts by hex nuts on adjustable core; core form is molded bakelite; 2 solder lug term; coil is 11 turns of # 26 wire; 17-1/2″ of wire; Wemco dwg # M-7408511-G2.
R RVA PA	L-701 L-1101 L-1856	2C446-78A/C1	COIL: IF tuning; brass core; adjustable; not plug-in; unshielded; approx 2″ lg x 11/16″ wd; mts by hex nut on adjustable core; coil is 23 turns of # 26 wire; 35″ of wire; Wemco dwg # M-7408511-G8, G9.
M	L-202 L-204	3C575-5	COIL, radio, RF: choke; integral type; section winding; universal; unshielded; 5 mh ±5%; 100 ma; DC, 25 kv; 11-1/8″ x 1″ diam; cloth base phenolic form, 1″ diam x 10-1/8″ lg; one end of coil mounted on hook shaped bracket, w/mtg hole 0.206″ diam; other end has 0.206″ diam mtg hole; one term at end of coil; vacuum impregnated; Wemco dwg # M-7416085.
ATU	L-501 L-502	3C324-25	COIL, radio, AF: choke, reactor; filter; 5 h at 0.2 amp; 90 ohms DC resistance; 0.75 kv insulation; untapped; metal case 4-5/16″ h x 3-1/4″ lg x 2-1/2″ wd over-all; Wemco # L-406445.
AETU	L-403 L-453	3C324-36	COIL, radio, AF: choke; reactor; anti-hunt filter; 60 cyc 1,900 h at 250v zero DC; 0.75 kv insulation; metal case; 2-1/2″ lg x 2-3/16″ wd x 4-7/16″ h over-all; Wemco # L-406447.
ARU	L-2103 L-2104	2C6996-1372/1	COIL, radio, video: pulse delay line; characteristic impedance 390 ohms for a 0.3 microsecond pulse delay; Wemco dwg # P7713507-G1.
PPU	L-1602	3C324-30	COIL, RF: choke; 91.8 mh ±1%; 330 ohms DC resistance ±10%; untapped; open type coil; mts on ceramic form 7/8″ h x 1″ diam; FW Sickles; Wemco # 7709155, part 1.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
R	L-705	2C5056A/C2	COIL, radio, RF: IF tuning adjustable brass core; not plug-in; unshielded; approx 2" lg x 11/16" wd; mts by hex nuts on adjustable core; molded bakelite coil form; 2 solder lug term; coil is 11 turns of #26 wire, 17-1/2" of wire; Wemco dwg #M-7408511-G4.
RU	L-601	3C324-29	COIL, RF: choke; 8 mh ±5%; 54 DC resistance ±15%; untapped; open type coil; mts on ceramic form 7/8" h x 1" diam FW Sickles; Wemco #7709155, part 3.
DU	L-101	3C324-26	COIL, radio, AF: choke; 1 mh ±2%; 10 ohms DC resistance ±10%; 125 ma current capacity; 4 pie winding; ceramic case 1-1/2" lg x 1-1/2" diam; Sickles spcl; Wemco #7811108.
ARR ReR	L-2201 L-1001	3C324-37	COIL, radio, AF: reactor; filter; swinging; 5 hy at 300 ma; 20 h at 0 ma; 107.3 ohms DC resistance; ±7% at 25°C; untapped; 6-1/4" lg x 4-9/16" wd x 4-19/32" h; Wemco #L-406420.
DU	L-102	3C324-31	COIL, radio, RF: choke; reactor; 2.1 mh ±2-1/2% at 125 ma; 35 ohms DC resistance; ±10%; 1.2 mmf distributed capacity ±5%; 5 pie 1/2" diam wound on ceramic form 1-1/2" lg x 1/4" diam; Wemco #7811110.
R RVA	L-707 L-1103	3C324-32	COIL, radio: IF choke; 300 mh; ±5%; 8 ohms DC resistance ±20%; 2.5 mmf distributed capacity; 1 pie, 1/2" diam wound on ceramic form 1-1/2" lg x 1/4" diam; two 1-1/2" lg x 0.40" diam axial wire leads; FW Sickles spcl; Wemco #7811107, part 1.
DU	L-105	3C324-33	COIL, radio, RF: choke; 1.8 mh ±5%; 7.5 ohms DC resistance ±10%; 4 pie 1" diam wound on bakelite form 2-7/8" lg x 1/4" diam; five #2664 term shakeproof; two #6-32 tapped mtg holes 3/8" d; Wemco #7811109.
M	L-203	3C324-41	COIL, radio, RF: choke; 2.5 mh ±5%; 30 ohms DC resistance; 5,000v; 10 pie, 21/64" apart; 965 turns #28 single cotton enameled wire, universal wound on phenolic form 6-1/2" lg x 1/2" OD; four crosses per turn; vacuum impregnated; unshielded; 6-1/2" lg x 7/8" OD; 2 mtg holes, 0.154" diam 6" centers; 2 #/6 term screws 3/4" from each end; Wemco #7408548.
R	L-703	2C5056A/C2	COIL, RF: IF tuning; adjustable brass core; 11 turns #26 wire; 17-1/2" of wire; approx 2" lg x 11/16" wd; Wemco dwg #7408511-G3.
PPI	L-1701	2C1557-1092A/1	COIL, video: focus coil; plug-in; one winding; unshielded; 3,450 ±1% turns of #27 enamel wire; DC resistance 20°C–120 ±10% ohms; 3-5/8" diam x 1-5/16" thk; Magnetic Winding Co; Wemco dwg #7409361, part 1.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
PPR	L-1501 L-1502	3C332-944	COIL, radio, AF: filter; one winding 3,000 turns; 10 h; 500 vdcw; 0.225 amps; 4-1/2" lg x 3-1/8" x 4"; Wemco L spec #386944.
SD	L-926	3C575-4	COIL, radio, AF: choke; filter reactor; single winding; 50 h min; 0.002 amp; 1,000 ohm DC resistance; Wemco #T-7614139-281.
OPS	L-951	3C575-14	COIL, oscillator FW Sickles #31-6037.
PPR	L-1503	3C575-15	COIL, radio, AF: 10 h; 0.125 amp DC; 92 ohm DC resistance; Wemco #L-spec #386945; Wemco dwg #T-7614139, part 266.
PPI	L-1702	2C1557-1092BC2	COIL, iron core: oscilloscope beam deflection; 8 windings; each coil part has pri and sec winding of 1,080 turns ea of #30 AWG enamel wire; 3-15/16" x 3-15/16" x 2-1/4"; Magnetic Winding Co; Wemco dwg #7409359.
M	L-201	2C1557-1371/C1	COIL, radio, AF: filament; single; 12 h; 0.1 amp; 160 ohms ±15%; 5-1/4" lg x 2-3/4" wd x 5-5/8" h; Wemco pt/dwg #406751.
ACR	L-1451	3C1987-72	COIL, retard: 3-5 h; 500 ma; filter choke; 5" x 4" x 4" can; leads from porcelain standoff insulators; Wemco #KS-8572.
ReR ARR	L-1002 L-2202	3C324-22	COIL, choke: reactor; filter; single winding; 300 ma; 110 ohms DC resistance; 3-3/8" lg x 2-13/16" wd; Wemco L-spec #406421; Wemco dwg #T-7614139, part 252.
PPU ReR ARR AETU LO	L-1601 L-1003 L-1004 L-2203 L-2204 L-403 L-405 L-1801 L-1802	3C332-406	COIL, radio, AF: filter; reactor; 12 h to 20 h swinging; 750 vdcw; 312 ohms ±15%; 2-1/2" diam x 3-5/8" lg; aluminum case; Wemco L-406406.
AETU	L-401 L-402 L-451 L-452	3C324-40	COIL, radio, AF: choke; filter; 1,850 h; 3,000 ohms; DC resistance; 260v 60 cyc; 0.75 kv insulation; untapped; metal case; 2-1/2" lg x 2-3/16" wd x 3-1/8" h; 4 mtg studs #8-32 thd x 5/16" lg; 1-15/16" and 1-11/16" centers; two solder lug term; Wemco L-spec #406755-E; Wemco dwg #T-7614139, part 255.
PPU	L-1603	3C575-12	COIL, radio, RF: choke; 4.25 mh ±5%; 39.3 ohms ±10%; FW Sickles; Wemco #7709155, part 4.
	L-801 L-802	3C575-16	COIL, AF: filter choke; single winding; 5h, 300v, 0.225 amp; 80 ohms DC resistance; 4-1/2" lg x 3" wd x 4-1/8" h; Wemco L-406417; Wemco dwg 7614139, part 272.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
		3H1004-2	COMPRESSOR: dielectric dwg #AD-27-1.
DU M ATU R RI RVA DUA PPU	P-101 P-205 P-509 P-703 P-705 P-903 P-907 P-909 P-1101 P-1402 P-1403 P-1404 P-1452 P-1606 P-1607 P-2003	2Z8671.27	CONNECTOR, female cont: socket; 1 cont; 1-61/64″ x 1-39/64″ x 1.036″; amphenol #AN-3108-14S-4S; GE dwg #K-7888627.
RU R PA	J-603 thru J-608 J-704 J-1853	2Z8671.37	CONNECTOR, female cont: socket; 1 cont; 1-3/16″ lg x 1-3/16″ sq; amphenol #AN-3102-14S-4S; GE dwg #K-7884245, part 3.
RaR PPR	J-804 J-1502	2Z8671.31	CONNECTOR, female cont: socket; 1 cont; amphenol #AN-3102-18-16S; Crosley dwg #W-220687-2; aluminum housing; bakelite insulation; w/flange; one #12 alloy socket cont; four 0.120″ mtg holes on 1-1/16″ centers.
RI OPS RVA PPU ARU	P-911 P-914 P-951 P-1104 P-1605 P-2108 P-2109	2Z8671.26	CONNECTOR, female: 1 cont; amphenol #80F1; GE dwg #K-7888695, part 1.
RaR ReR FS DUA PPR LO TrL ARR	P-801 P-1003 P-1151 P-1453 P-1501 P-1801 P-1983 P-2202	6Z3150-10	CONNECTOR, female: GE #2720; 10 amp; 250v 15 amp; 125v; w/cord grip 3/8″ to 1/2″; GE dwg #K-7888670, part 1.
CP	P-1757	2Z8672.27	CONNECTOR, female cont: 2 cont; (threaded; nickel pl; metal body; 17/32″ diam x 1-1/2″ lg; amphenol #MC-2-F1).
DU RI	J-101 J-903 J-907 J-909	2Z7111.94	CONNECTOR, female cont: plug; single cont; (aluminum flange and shell; bakelite base; 23/32″ OD x 1-9/64″ over-all lg; AN-3102-14S-4P; GE dwg #K-7884245P).
RaR PPR	P-804 P-1502	2Z7111.18	CONNECTOR, male: 1 cont; amphenol #AN-3108-18-16P; 1-7/8″ h x 2-5/8″ lg.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
RI RI OPS RVA PI PPU ARU	J-911 J-914 J-951 J-1104 J-1208 J-1605 J-2109	2Z8671.29	CONNECTOR, male cont: socket; 1 cont; amphenol #80-C1; 5/8″, 27 thd; heavy brass shell; black bakelite insulation.
DUA	P-1491	2Z7112.21	CONNECTOR, male cont: plug; coaxial cable; 2 cont; brass springs; cadmium pl brass shell, and knurled coupling ring; 11/16″ OD x 1-3/8″ lg; cord protector spring 3/4″ lg; amphenol #MC2M.
DP	J-1906	2Z3023-19	CONNECTOR, male cont: receptacle; Army Ordnance #C78536; 3 round male cont; polarized; straight; 3-1/2″ x 3-1/2″ x 3″ lg; Pyle-National per Ordnance #C78536; Wemco dwg #7409467, part 2.
M	J-208	2Z7113.1	CONNECTOR, male cont: plug; 3 cont; 2″ sq base for mtg; 31/32″ x 1-1/2″ diam; amphenol #AN-3102-28-3P.
TrL	J-1988	2Z8672.35	CONNECTOR, female cont: socket; 2 cont; 1-5/16″ lg x 1-1/16″ diam; (amphenol #PC2F, Philco #358-4296; spring brass, cadmium pl; bakelite insulation; shell brass, cadmium pl; mts in 5/8″ diam hole; u/w amphenol #MC2M connector).
M	P-208	2Z3064-15	CONNECTOR, female: 3 #8 cont; 3/16″ spacing; right-angle type; diam 1 end 1-31/32″; diam other end 1-7/16″, 18 thds; over-all lg 3-13/16″; AN-3108-28-3S; Cannon Elec Co type #AN-3108-3S; Wemco.
TrL	J-1987	2Z3063-22	CONNECTOR, female: 2 #12 cont; 1/8″ spacing; straight type; 2-5/64″ lg; AN-3100-22-8S; Cannon Elec Co part #2045-16.
M LO	P-204 P-1807	2Z3066-14	CONNECTOR, female: 2 #12 cont; 3 #16 cont; 3/16″ spacing; right-angle type; 3-1/4″ lg x 1-7/16 diam 1 end; 1-23/32″ diam other end; AN-3108-24-17S; Cannon Elec Co.
LO	J-1807	2Z3066-12	CONNECTOR, female: 2 #12 cont; 3 #16 cont; 3/16″ spacing; straight type; 2-1/4″ lg x 1-3/4″ diam; AN-3100-24-17S; Cannon Elec Co.
CP	J-1754	2Z3066-11	CONNECTOR, female: 2 #12 cont; 3 #16 cont; 3/16″ spacing; straight type; 2-1/4″ lg x 1-3/4″ diam; AN-3102-24-17S.
R RI	J-701 J-904 J-905	2Z7115.3	CONNECTOR, male: 3 prong; amphenol #AN-3102-16S-5P 1-9/32″ x 1-9/32″ sq flange x 1-1/16″ lg over-all; shell type for box or chassis mtg; has matched 1″, 20 coupling thd to fit AN type plugs.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
RU FS CP	P-610 P-1153 P-1751	2Z7113.20	CONNECTOR, male cont; plug; 3 cont; (2-1/16" x 1-3/4" x 1-5/32"; amphenol #AN3108-16S-5P; GE dwg #K-7888629-P2).
OPS	J-953	2ZK7409-2	CONNECTOR, male cont: plug; 4 cont; box mtg; aluminum alloy; 1-3/8" x 1-3/8 x 1-9/16"; ref J-902; AN-3102-184P.
RaR PI	P-802 P-1201 P-2007	2ZK7132-4	CONNECTOR, male cont: plug; aluminum shell; molded bakelite; 90° connector; 4 #12 cont; 1/8" spacing; 18 #16" cont; 1/8" spacing; 1 end w/coupling rings; 2-15/32" OD; 2-1/4", 16 thd; other end 2", 18 thd; Amphenol #AN-3108-36-1P.
PPI RI	J-1701 J-906 J-908	2Z7114.30	CONNECTOR, male cont: plug; 4 cont; 1-61/64" x 1-7/64" diam; Amphenol #AN-3100-18-4P.
RU RU PPU ARU	P-601 P-602 P-1604 P-2103	2Z7114.11	CONNECTOR, male: 4 cont; Amphenol #AN-3108-18-4P; 2-5/8" lg x 1-7/8" h, #16 cont.
ACCU	J-1406	2Z7118.22	CONNECTOR, plug: 8 cont; 1-3/8" lg x 1-1/2" sq; Amphenol #AN-3102-20-7P.
M RU R DUA	P-203 P-603 P-604 thru P-608 P-702 P-704 P-706 P-1407	2Z7111.33	CONNECTOR, male cont: plug 1 cont; (1-3/4" over-all lg x 1-5/8" h x 1-1/16" diam; GE dwg #K-7888627, part 2.
R RI OPS PPU	P-709 P-913 P-952 P-954 P-1608 P-2101 P-2106 P-2111 P-2112 P-2118	2Z7226-259	CONNECTOR, male: PL-259; single cont; Amphenol #83-1SP.
RI		2Z2712.33	CONNECTOR, cinch type: Wemco dwg #7811994, part 1; Wemco part/dwg #T-7614152, part 902.
RU PPU	J-601 J-602 J-1604	2Z8674.52	CONNECTOR, socket: 4 cont; AN-3100-18-4S; Wemco part/dwg #T-7614138, part 203.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
ATU R RaR ReR PI PPU GP ARU ARR	J-508 J-707 J-803 J-1001 J-1002 J-1206 J-1601 J-1752 J-1758 J-2110 J-2201	2Z8678.68	CONNECTOR, female cont: socket; receptacle; 8 cont; Amphenol AN-3102-20-7S; 1-3/8″ lg x 1-1/2″ sq; GE dwg # K-7885404, part 3.
OPS	P-953	2ZK7114.19	CONNECTOR, female cont: plug; straight; aluminum; 4 #16 socket cont spaced 1/8″; 1-5/16″ diam x 2″ lg; Amphenol # AN-3106-18-4S.
R RI	P-701 P-904 P-905	2ZK7113.8	CONNECTOR, female cont: plug; 90°; 3 cont; aluminum alloy; socket type cont for #16 AWG wire; over-all dimen 1-7/8″ x 1-3/4″; Amphenol # AN-3108-16S-5S.
RaR ReR RVA PPR LO ARR	J-801 J-1003 J-1151 J-1501 J-1801 J-2202	6Z7813-4	CONNECTOR, female cont: receptacle; motor base; 2 wire; large size; nickel pl; 10 amp 250v; 15 amp 125v; GE #2291; GE dwg # K-7886283, part 1; ref #289.
ATU R RaR ReR ReR PI DUA DUA PPU CP ARU ARR	P-508 P-707 P-803 P-1001 P-1002 P-1206 P-1405 P-1451 P-1601 P-1752 P-2008 P-2110 P-2201	2Z7118.21	CONNECTOR, male cont: plug; 8 cont; 90° angle plug w/coupling ring; over-all lg 2-15/16″ x 2″ h; 3/4″ conduit; # AN-3108-20-7P; GE dwg # K-7888626, part 2.
CP	P-1758	2Z7118.14	CONNECTOR, male cont: plug; 8 cont; aluminum shell pin insert; 1-15/32″ diam x 2-1/8″ lg; Amphenol # AN-3106-20-7P.
M	J-206	2Z3028-6	CONNECTOR, male: 8 #16 cont; four 1/8″ spacing; four 1/16″ spacing; straight; Amphenol AN-3100-20-7P.
CP	P-1756	2Z7122.27	CONNECTOR, male cont: plug; 12 cont; straight; inserts Amphenol #97-3106-28L32-8S w/special black shell; over-all lg 21/41″ w/ 1-3/4″, 18 thd; Amphenol # AN-3106-28-8S; Belrad dwg # B-55A-4068.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
DU AETU PPU PPI CP	P-102 P-408 P-1602 P-1702 P-1753 P-2004	2Z8682.8	CONNECTOR, female cont; AN-3108-28-8S; type PE plugs; 2 #12, M-110v and 10 #16 A-H incl-24v; 90° angle type 6 & 7; over-all lg 3-3/8″ w/coupling wd 00 1-31/32″; split shell; Cannon Elec Co, part #W02191-38.
M	P-209	2Z72260224	CONNECTOR, female: 1 #12 cont; high tension; 5/16″ spacing; right-angle type; over-all lg 2-7/16″ lg; AN-3108-18-16S; elbow shape; split shell; Amphenol #102.
CP	P-1755	2Z3069-6	CONNECTOR, female: 8 #16 cont; four 1/8″ spacing; four 1/16″ spacing; straight; 2-1/8″ lg; AN-3106-20-7S.
DU AETU PPR PPU PPI CP	J-102 J-408 J-1576 J-1602 J-1702 J-1753	2Z7122.2	CONNECTOR, male cont: plug; (12 pin; 2 #12 cont; 10 #16 cont;) Amphenol #AN-3102-28-8P.
AETU	J-409	2Z8799-184	CONNECTOR, male: 4 #12; 18 #16 cont; 1/8″ spacing; straight type; over-all dimen 1-7/16″ lg x 2-1/2″ x 2-1/2″; 1 end threaded 2-1/4″, 16″; Amphenol type #AN-3102-36-1P.
M PI DUA PPR PPU ARU	P-207 P-1202 P-1401 P-1503 P-1603 P-2105	2Z7122.6	CONNECTOR, male cont: plug; 12 prong; modified; elbow type 3-3/16″ x 1-31/32″ diam; aluminum shell; bakelite insert; modified to enlarge term A, B, C to fit #12 AWG wire; Amphenol #AN-3108-28-SP.
M PPR PPU PI	J-207 J-1503 J-1603 J-1202 J-1203	2Z8682	CONNECTOR, female cont: socket; 12 cont; 1-3/4″ over-all lg; Amphenol #AN-3102-28-8S; (aluminum; flange 2″ sq; coupling end 1-3/4″, 18 thd; 4 mtg holes 0.147″ diam on 1-9/16″ centers; 2 #21, and 10 #16 cont; ref PL-6 for PE-110-A, C).
M M	P-210 P-211	2Z8671.57	CONNECTOR, female cont: socket; straight; 1 cont; round prong; selector type JNRM-16-2; GE dwg #M-7469957P2; (body zinc sealed w/polystyrene; no cord clamp; 4 mtg hole 0.125″ diam, mtg/c 0.719″ x 0.719″; mtg bracket 1″ x 1″ x 0.078″ thk; hole for outer cable jacket 0.405″ diam; hole for cable shield 0.277″ diam; shell of receptacle 5/8″–24 thd; p/o cable GE #ML-7469575-G1 cable assembly).
R RI OPS TrL TrL TrL ARU	J-709 J-913 J-952 J-1984 J-1985 J-1986 J-2101	2Z8799-239	CONNECTOR, socket SO-239: female; single cont; dwg SC-D5850; (for use w/plug PL-259; takes socket hood M-360 where complete shielding of cable lead is required).

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
RU	J-601	2Z8674.52	CONNECTOR, female cont: socket; 4 cont; # AN-3100-18-4S; (17/64″ x 1-61/64″ lg; skirt 1-3/8″ sq).
	J-602		
PPU	J-1604		
LO	P-1803	2Z3062-71	CONNECTOR, female plug: 1 round female cont; straight; 1-1/8″ lg x 1/2″ OD; Sperry Gyro type SKL; Wemco dwg # T-7614140, part 307.
DU	J-103	2Z7235-1	CONNECTOR, female cont: Amphenol type 80-C.
M	J-201		
	J-202		
RI	J-912		
RVA	J-1102		
ARU	J-2104		
	J-2106		
	J-2107		
	J-2111		
LO	J-1804	2Z8671.57	CONNECTOR, female: receptacle; 1 cont; round prong; 4 holes for panel mtg; for RMA-16 cable; Ucinite type N.
RaR	J-802	2ZK8692-4	CONNECTOR, female cont: socket; 22 cont; (1-3/4″ over-all; Amphenol # AN-3102-36-15; 4 # 12 and 18 # 16 cont; mtg flange 2-1/2″ sq; coupling thd 2-1/4″, 16; max conduit 1-1/2″).
PI	J-1201		
DP	J-1905	2Z3065-14	CONNECTOR, female cont: 4 rectangular cont; duplex convenience outlet; std item; 15 amp 125v; 10 amp 250v; Bryant Elec # 4832.
TrL	J-976		
	J-1978		
	J-1982		
	J-1983		
RVA	J-1101	2Z8799-135	CONNECTOR, socket SO-135: wall mtg receptacle; part # AN-3100-14S-4P; dwg # AN-9534 (fits plug PL-191, PL-Q191).
ATU	J-509		
M	J-205		
PPU	J-1606		
PPU	J-1607		
R	J-703		
R	J-705		
ACCU	J-1402	2Z7111.94	CONNECTOR, female: plug AN-3102-14S-4P; single cont; aluminum flange and shell; 9/16″ mtg flange x 1/16″ thk x 1-9/64″ lg over-all; Cannon # 2027-5.
	J-1403		
	J-1404		
ACR	J-1452		
ACCU	J-1407	2Z8671.37	CONNECTOR, socket: 1 cont; 1-3/16″ lg x 1-3/16″ sq; Amphenol # AN-3102-14S-4S.
CP	P-1754	2Z3006-13	CONNECTOR, 5 round female cont: straight; 2-1/4″ lg x 1-23/32″ diam; Amphenol # AN-3106-24-17S.
ACCU	J-1405	2Z8678.68	CONNECTOR, socket: 8 cont; 1-3/8″ lg x 1-1/2″ sq; Amphenol # AN-3102-20-7S.
ACR	J-1451		

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
ACCU	J-1401	2Z8682	CONNECTOR, female: socket; 12 cont; flange 2" sq; 1-3/4" over-all lg; Amphenol #AN-3102-28-8S.
M	J-204	2Z3066-12	CONNECTOR, female: AN-3100-24-17S; 2 #12, 3 #16 cont; 3/16" spacing; 1-3/4" x 1-3/4" x 2-1/4"; Amphenol #3100-24-17S; Wemco dwg #T-7614137, part 196.
RI PPI	P-906 P-908 P-1701	2Z8674.4	CONNECTOR, female cont: socket 4 cont; Amphenol #AN-3108-18-4S; (4 #16 socket cont; 1/8" spacing; 10 amp; molded low loss insulation; split type aluminum shell; 90° angle L shaped; 1-15/16" lg x 1-1/8"; coupling ring thd 1-1/8", 18; cable end thd 1", 20).
ARU	J-2103	2Z8674.21	CONNECTOR, female cont: socket; 4 cont; Amphenol #AN-3102-18-4S; (conduit 5/8" flange; 1-3/8" sq; cont for #16 AWG; coupling 1-1/8" thd; 4 mtg holes 0.120" diam; 1-1/16" between centers).
RU FS PPI	J-610 J-1153 J-1751	2Z8673-33	CONNECTOR, female cont: socket; 3 cont; 1-3/16" lg x 1-3/8" sq; (Amphenol #AN-3102-16S-5S; GE dwg #K7886859, part 3).
M R	J-203 J-702 J-706	2Z8671.40	CONNECTOR, female cont: socket; 1 cont; 53/64" OD x 1-5/16" lg; Amphenol #AN-3100-14S-4S; (skirt 1-3/16" sq).
		2Z3018-21	CONNECTOR, magnetron: preplumb; LH Terpening #A-270-35; phosphor bronze; over-all dimen 2-11/16" x 0.375".
ACR	J-1453	6Z7813-4	CONNECTOR, receptacle: motor base 115v; Rich-Allen #2291.
 RU	J-916 J-2118	2Z8799-239	CONNECTOR, male: Navy #CPN-49194; Sig C #50-239; single round female cont; 1-1/16" lg x 1" sq; Amphenol #83-1R; Wemco dwg #T-7614138, part 218.
CP RI	J-1757 J-917	2Z3022-48	CONNECTOR, male: 2 pin; 1-1/16" OD x 15/16" lg; Amphenol #PC2M; Wemco dwg #T-7614137, part 192.
AETU ATU RU R RI SD RVA PI CP PA ARU	J-410 J-507 J-609 J-708 J-902 J-926 J-1103 J-1204 J-1755 J-1851 J-2102 J-2105	2Z7118.22	CONNECTOR, male cont: plug; 8 cont; Amphenol #AN-3102-20-7P.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
M AETU ATU RU R RI SD RVA PI DUA ARU	P-206 P-410 P-507 P-609 P-708 P-902 P-926 P-1103 P-1204 P-1406 P-2005 P-2102 P-2105	2Z8678.44	CONNECTOR, plug: female cont; right angles; Amphenol # AN-3108-20-7S.
RI PPI	J-410 J-1703	2Z8799-204	CONNECTOR, socket SO-204: box mtg receptacle; 1 # 12 cont rated 14,000v peak; # AN-3102-18-16P; (spec AN-W-C-591).
RI PI PCU	J-901 J-1203 J-1301	2Z8799-184	CONNECTOR, socket SO-184: electrical connector; Spec-AN-9534A; box mtg receptacle; 4 # 12; 18 # 16 conts; rated for 200v peak service; fits plug PL-P244; # AN-3102-36-1P w/Sig C type number on socket shell.
DP	J-1901 thru J-1904	2Z3039-4	CONNECTOR, male cont: receptacle; Army Ordnance # 669409; 19 round male cont, polarized; straight; 3″ x 3″ x 2″ lg; Pyle-National cat # 1100 PEP; Wemco dwg # M-7408855, part 5.
RI PPI	P-910 P-1703	2Z7226-Q224	CONNECTOR, plug PL-Q224: right-angle; AN-3108-18-16S; 1 # 12, 7 # 16 cont; Wemco dwg # T-7614140, part 328.
AETU RI PI PCU	P-409 P-901 P-1203 P-2006 P-1301	2Z7226-Q244	CONNECTOR, plug PL-Q244: right-angle; AN-3108-36-1S; 4 # 12, 18 # 16 cont; Wemco dwg # T-7614140, 318.
RI RVA ARU	P-912 P-1102 P-2104 P-2107	2Z7235	CONNECTOR, male: for transmission line; Amphenol type 80-M.
		2C680-1085C	CONTROL UNIT BC-1085-C: (positioning) Wemco # DL-7502463-G2.
		2C680-1094C	CONTROL UNIT BC-1094-C: altitude converter; Wemco # DL-7502464-G2.
		3H370	COUPLING ASSEMBLY, fan: rubber and steel coupling assembly for motor generator set; approx 6″ diam x 2-3/16″ thk; Wemco Lima Works part/dwg # 7-B-8428; Wemco # M-7411001-P5.
		2Z3273-41	COUPLING ASSEMBLY: shaft and bearing axial; steel and brass; 7″ lg x 5-5/8″ diam (over-all); Palmer-Bee Co; u/w 7709390 part 1; Wemco dwg # M-7417540, part 45.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
		2Z3291-9	COUPLING: flexible insulated rings 1-1/4″ diam; 2 phosphor bronze straps w/brass bushing; Wemco #T-7607465G-19.
		2C765A	CRYSTAL MIXER BC-1130-A: Wemco #DL-7502482-G2.
RU	Y-601 Y-602	2X83-81.95	CRYSTAL UNIT: GE type #53, w/transmitting XTAL housed in metal can; over-all dimen 3-5/32″ h x 1-5/16″ diam; two 35/64″ lg x 7/16″ diam std tube socket prongs.
		3H1170	CYLINDER, gel: copper and brass; nickel-plated; to hold silica gel; 110v, 60 cyc, approx 10w; 10-11/16″ x 5-7/8″ x 4-3/4″ (approx); Dielectric Prod Co dwg #AD16-AD-1; Wemco dwg #M-7416899, part 3.
		2C7891-1075A	DATA UNIT BC-1075-A: (altitude converter) Wemco #DL-7502464-G2.
		2Z3602-14	DEHYDRATOR, auto: sheet steel housing; black crinkle finish; 115v; 60 cy; approx 15 amps; over-all dimen 16-7/16″ wd; 15-21/32″ h; approx 17-1/4″ lg; Dielectric model 22J; Wemco #T-7614149, part 778.
		2Z3775-4	DIAPHRAGM: Dielectric dwg #AD-25-3.
		2Z3806.3	DISK, check valve: neoprene 1/2″ diam 1/8″ thk; Dielectric Prod #AD-24-5; Wemco #M-7416899, part 5.
		2Z3806.5	DISK, compressor exhaust valve: Dielectric dwg #AD-25-1 Minneapolis part No. GX19 Cornelius Co.
		2C6900-108C	DRIVER UNIT BC-1080-C; Wemco #DL-7502471-G2.
		6Z3429-8	FITTING, purge orifice: stainless steel; 1/4″ IPS male x 7/16-20; over-all dimen 9/16″ diam x 1-1/8″ lg; Dielectric Prod part/dwg #AD-18-5; Wemco dwg #M-7416899, part 10.
DU M RaR LO	F-101 thru F-104 F-205 F-206 F-801 F-802 F-1801 F-1802	3Z1950	FUSE, FU-50: 3 amp; 250v; glass body; nickel pl ends; 1-1/4″ lg x 1/4″ diam; Littelfuse type 3AG-1043; RCA dwg #K8050339, part 14.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
ATU RaR ReR FS PPR DP ARR	F-501 F-502 F-803 F-804 F-1001 F-1002 F-1153 F-1154 F-1501 F-1502 F-1910 F-1911 F-2201 F-2202	3Z2605.2	FUSE, 5 amp: 250v; 1-1/4″ lg x 1/4″ diam; Littelfuse #3AG-1358; or Bussman MTH.
ACR	F-1451 F-1452	3Z1925	FUSE, FU-25: cartridge; 5 amp 25v; 1/4″ diam x 1-1/4″ lg; Littelfuse type 3AG-1080.
M	F-203 F-204	3Z1921	FUSE, FU-21: 10 amp; 25v; Air Corps spec 94-32271; glass enclosed; 1-1/4″ lg 1/4″ diam; Littelfuse type 3AG-#1081; (p/o BC-412; ref F1A & F2A for Radio Transmitter BC-400-A; Bendix #A12247-5).
TrL	F-1976 thru F-1981	3Z1931	FUSE, FU-31: cartridge; 10 amp; 250v; Fed spec W-F-803; renewable; ferrule cont; 2″ lg x 9/16″ diam; Buss Super-Lag 1010; (3Z3010 is used to renew fuse, ref 403 for Dynamotor Unit PE-62-A; Wemco style S1252684; dwg #T-7606616, part 14.
M	F-207 F-208	3Z1926	FUSE, FU-20: 1 amp; 250v; Air Corps spec #94-3227; glass inclosed; 1-1/4″ lg x 1/4″ diam; Littelfuse type 3AG-1040 or equal.
AD		3Z1924	FUSES, cartridge: 15 amp; 25v; 1 time; glass; ferrule type; caps nickel pl; 9/32″ OD x 1-1/4″; Buss per Dielectric Prod Co pt/dwg AD-26-5; Wemco dwg #M-7416899, part 13.
M DP	F-201 F-202 F-1901 thru F-1909	3Z2625-1	FUSE, cartridge: 25 amps; 250v; ferrule type 2″ over-all diam of tube +2″ diam over ferrules 9/16″; supply cartridge complete with link.
		2Z4868.54	GASKET, M: neoprene; soft; LH Terpening #A-270-14; 1-5/16″ OD x 1-1/8″ ID x 1/16″ thk.
		2Z4868.55	GASKET, M nut: neoprene; soft; LH Terpening #A-270-15; 1-3/8″ OD x 17/32″ ID x 1-3/8″ thk.
M		2Z4867.74	GASKET, neoprene: 15/64″ OD x 1/8″ ID x 1/16″ thk; Wemco dwg #T-7610525-P-912; MIT dwg #C-1975-1.
M		2A2704-61A/G1	GASKET, neoprene: crystal mixer; 0.718″ OD x 19/32″ ID x 0.062″ thk; Wemco #T-7610525P-939; Mit dwg #C-2587-V.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
		2Z4866.83	GASKET, neoprene: GE #7889324; (soft, 1″ x 1.281″ x 0.632″ x 0.065″ thk).
		2Z4868.63	GASKET, neoprene: soft; Lambert Meter Co; GE dwg #K7888790, part 7; (1″ OD x 0.747″ ID x 3/64″ thk).
		2Z4868.62	GASKET, Tr box: neoprene: 15/16″ OD x 0.680″ ID x 0.093″ thk; GE dwg #K-7888790, part 4.
		2Z4868.61	GASKET, Tr box: 1.718″ OD x 1.159″ ID x 0.065″ thk; neoprene; GE dwg #7888790, part 3.
		2Z4868.50	GASKET, antenna housing vent cap: neoprene; LH Terpening #A-270-101; OD 3/8″ x 1/16″ thk.
		2Z4868.51	GASKET, antenna: neoprene; LH Terpening #A-270-100; 19/32″ OD x 15/32″ ID x 1/8″ thk.
		2Z4868.52	GASKET, antenna OC: neoprene; LH Terpening #A-270-99; 1-1/8″ OD x 1″ ID x 1/8″ thk.
		2Z4868.49	GASKET, cap: weather; neoprene; soft; LH Terpening #A-270-288; ID 1-1/8″ x OD 1-1/2″ x 1/8″ thk.
		2Z4866.172	GASKET, copper asbestos: for dust filter assembly; Dielectric dwg #AD-17-5.
		2Z4868-48	GASKET, coupling flange: neoprene; LH Terpening #A-270-13; ID 0.970″ x OD 1.147″ x 0.025″ thk.
		2Z4867.180	GASKET, crystal mixer: MIT dwg #C-1975-H.
		2Z4866.158	GASKET, lead: for compressor valve; Dielectric dwg #AD-25-4.
		2C1557-1088A/G1	GASKET: micarta #464; strip 8-3/4″ lg x 1-1/2″ wd x 1/8″ thk; 3 holes 0.180″ diam; Wemco dwg #7811312, part 1.
		2Z4868.53	GASKET, antenna choke: neoprene, LH Terpening #A-270-98; ID 1-1/16″ x OD 1-1/4″ x 1/8″ thk.
		2A275-101A/G1	GASKET: transmission line; disk shape or type (4 & 5) semi-glossy black finish applied to brass screws or similar brass parts; 5-1/16″ over-all diam, 4-7/16″ ID x 0.020″ thk; three holes 0.206″ diam equally spaced; Detroit Gasket & Mfg Co #7814592.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
		2A275-101A/G2	GASKET: transmission line; disk shape; semi-glossy black finish applied to brass screws or similar brass parts; 3-7/8″ over-all diam 2-13/16″ ID with four mtg equally spaced apart 9/32″ diam of holes; 0.020″ thk; Detroit Gasket & Mfg Co #7814593.
		6Z4251-12	GAUGE, pressure: Dielectric dwg #AD-27-3.
		6G585.3	GEL, indicating: 1/2-pt can; Dielectric dwg #AD-26-1.
TrL	B-1976 B-1977	3H2411-4	GENERATOR, AC: 1 hp; 3 phase; motor; 250v, 2 amps; Wemco #7409170, part 1.
		6Z4870-1	GROMMET KIT: consists of grommet, Brodine Mfg Co #508; grommet, Wemco S #188710; grommet, Kiehl Mfg Co mold #3055 or equal; grommet, Brodine Mfg Co #2283; grommet, Brodine Mfg Co #2273; rubber extrusion, Brodine Mfg Co #X-155; Wemco dwg #M-7417192.
		6L80086	HARDWARE KIT: std; for range indicator; position indicator, and positioning control units; Palmer-Bee Co; Wemco dwg #7417540-G5.
		6L80087	HARDWARE KIT: std; Wemco dwg #7417190-G2, G3.
	R-1976 thru R-1981	2Z5015-68	HEATING ELEMENT, electrical: fin; 115v, 350w; single sect; flat strip, black metal; 12″ lg x 1-1/2″ h x 1″ thk; Wemco style #1145436.
PPU	J-1617	2Z5040-360	HOOP: M-360 Army dwg SC-B-5849-SC-5918; (a shield fitting to fit over the rear of Socket SO-239 and the connecting cable; provides shielding at the rear cont of the socket).
M DP	F-201A F-1901A F-1904A F-1907A F-1976A F-1977A F-1978A F-1979A F-1980A F-1981A	3Z2831-2	HOLDER, fuse: block type; holds three 30-amp cartridge fuses; clip type; 3-5/16″ x 4-1/16″ x 1-1/2″; porcelain base; Wemco S301571; Bryant 1924; Wemco dwg T-76068568.
DP	F-1910A	3Z3285-6.1	HOLDER, fuse: blocktype; side barrier for 2 fuses; porcelain base; clips spring bronze; nickel pl; Buss #4397; solder terms and tinned clips on spare fuse holder are steel; diam of base 1.594″ x 2.125″; 1 pole has 1 hole for 1/4″ fuses; 2 pole has 2 holes for #8 RH screws; 4 terms.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
AD		3Z2855-3.2	HOLDER, fuse: retainer for 1/4" x 1-1/4" and 9-3/32" x 1-1/4" fuses; black bakelite; copper plated clips; 18 amps; over-all dimen 2-3/8" lg x 3/4" diam; Buss per Dielectric pt/dwg AD-26-4; Wemco dwg #7416899, part 12.
DU	F-101A F-102A F-103A F-104A	3Z3275-1	HOLDER, fuse: post; Littelfuse #1075A (takes panel up to 5/16" thk; mtg hole 1/2" lg; 2-1/8" from front of panel; over-all lg 2-1/2"; for 3 AG fuse).
M	F-203A F-204A F-205A F-206A F-207A F-208A		
ATU	F-501A F-502A		
RaR	F-801A F-802A F-803A F-804A		
ReR	F-1001A F-1002A		
RVA	F-1153A F-1154A		
ACR	F-1451A F-1452A		
PPR	F-1501A F-1502A		
LO	F-1801A F-1802A		
ARR	F-2201A F-2202A		
		2A288A-8/H-1	HOUSING ASSEMBLY ANTENNA: LH Terpening #B-270-83.
		2C1557-1092C	INDICATOR BC-1092-C; (position) Wemco #DL-7502462-G2.
		2C1557-1370	INDICATOR-CONTROL UNIT BC-1370.
M	P-030 P-031	3G1350-108	INSULATOR, bushing: modulator; metal tube shell w/conductor down center; porcelain; 12-1/8" x 4-1/2" over-all dimen; Wemco dwg #7709297-G1.
M		3G1839-35	INSULATOR, bushing: 1-1/8" over-all; 3/8" thk; inside diam 41/64"; Wemco dwg #7811289, part 1; rim 7/8" diam, fits into shaft hole.
PCU ReR		3G1250-8.13	INSULATOR: glazed porcelain; round; 1/2" lg 5/8" diam; Star Porcelain #7811164, part 1.
M		3G1250-84.1	INSULATOR, stand-off: cylindrical; brown color; glazed finish porcelain; 4" diam x 5-1/2" h; Wemco dwg #7811288, part 1; 5/8", 11 top; 7/8" wd both ends; 4" diam x 5-1/4" h.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
M		3G1250-16.37	INSULATOR, stand-off: cylindrical; ceramic, glazed; 1-3/4″ diam x 1″ lg; Isolantite cat #331-L1; 4 tapped holes #10-32 spaced 90° apart, located on 1-1/4″ circle; tap is 3/8″ wd.
PPR RaR		3G1550-32	INSULATOR, stand-off: ground mica filler; tan color; 2″ lg x 9/16″ sq; GE dwg #K7886865, part 1.
CP RI		3G1838-32.22	INSULATOR, stand-off: mica filled bakelite; Wemco #7610521, part 729; 2″ lg x 9/16″ sq.
RI		3G1450-30	INSULATOR, stand-off: ceramic Isolantite #342-L-1-718; 1-7/8″ lg x 3/8″ sq.
RI		3G1250-8.12	INSULATOR, stand-off: ceramic; 3/8″ diam x 1-1/2″ lg; 1 hole in each end; #6-32 tap; 3/16″ wd; Isolantite #395-L-1/2.
M		3G1837-32.19	INSULATOR, stand-off: rectangular shape; 3/4″ diam x 1″ lg; Wemco #5867534; 2 mtg holes 3/16″ d, for #8-32 thd.
M		3GK1250-16.15	INSULATOR, stand-off: Isolantite #381; 7/16″ diam top, 7/8″ diam base, 1″ h; hole in top and bottom 3/8″ d; #6-32 tap; WECo #BA-10000-2.
M		3G1785-12	INSULATOR, transmitter: treated fabric #0-1267; 4 layers thk; Wemco dwg #K-7812934; two holes 3/16″ diam, 1/2″ from edge of insulator 1″ x 1″ x 3/4″ thk.
AETU PPR ReR R		2C6530-653A/J6	INSULATOR: tube and transformer; GE dwg #K-7882855, part 1.
		3G1250-16.6	INSULATOR, stand-off: round post; glazed ceramic; 1″ lg ±1%; Isolantite type #395L-1; Wemco dwg #7614151, part 865.
		6G237.1	INSULATING COMPOUND: ignition sealing; clear translucent gel in lead foil 8 oz tube; 8″ lg x 3″ wd x 2″ thk; Dow Corning Corp Ignition Sealing Compound #4 med; Wemco dwg #7614151, part 890.
TrL	J-1977 J-1979 J-1980 J-1981	2Z5534A	JACK, JK-34-A: telephone; headset; 2 cond; over-all dimen 1-1/4″ x 1″ x 3/4″ h; accommodates plug PL-55.
AETU	J-401 thru J-407 J-411 thru J-414	2Z5581-12	JACK, telephone: for std 0.080″ phone tip; black; Amphenol #78-1P.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
	J-451 thru J-457		
ATU	J-501 thru J-506		
	J-510		
RU	J-611 thru J-625		
RI	J-915		
ACCU	J-1408 thru J-1412		
ACR	J-1454		
PPU	J-1606 thru J-1616		
LO	J-1805		
	J-1806		
ARU	J-2112 thru J-2117		
		2Z3270-320	JOINT, slow speed rotating: LH Terpening #C-447-50.
		6L995-40	KEY, woodruff: nick or carbon steel; 3/4″ x 1/8″ thk; Wemco Lima Works; Woodruff key #406; Wemco dwg #7411001-P6.
CP		2Z5788-59	KNOB: bar type; black moldarta; 2 #8-32 setscrews; 2-1/2″ wd, 1-11/16″ lg, 1-1/2″ diam; Wemco dwg K-7818113, part 1, shaft hole 11/18; counterbored by 3/16″ drill for setscrews.
		2Z5837-22	KNOB: round; bakelite; shaft diam 1/4″; 1 #8-32 setscrew; numeral 0-5 marked on metal extension; Wemco dwg #7610522P-756; Bloomfield dwg BE-32744.
		2Z5786.68	KNOB, round: black moldarta; 1/4″ shaft diam, #8-32 setscrew, 2 holes; 7/8″ x 7/8″ x 15/16″; Wemco dwg #7408709, group.
		2Z5842.19	KNOB, round with baron top; black bakelite; 1/4″ shaft diam; mts w/1 #8-32 setscrew; overall diam 1-1/2″ x 1-11/16″ h x 2-7/16″ lg; Wemco #80-2308.
		2Z5753.13	KNOB: round w/pointer 1/16″ lg; tan bakelite; 1/4″ shaft; 2 #8-32 setscrews; Wemco dwg #7708220, part 2.
TrL		6Z6814-6	LAMP, LM-57: incandescent; mazda #64; 6-8v; 3 CP; G-6; bayonet base; double cont; auto type.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
DP	I-1901A	2Z5941	LAMP, LM-41: incandescent; 110v, 6 w; Mazda #6S6 (clear, candelabra screw base; G-7A fil; type B).
ATU RU R RaR RI ReR PI PPR PPI CP LO ARU ACR DUA	I-501A I-601A I-701A I-801A I-802A I-901A I-1001A I-1201A thru I-1206A I-1501A I-1701A I-1702A I-1703A I-1751A I-1752A I-1753A I-1754A I-1801 I-2101 I-1451 I-1491	2Z5927	LAMP, LM-27: incandescent; 6-8v; 0.25 amp; minature bayonet base; Mazda #44.
ACCU	R-1406 R-1407	6Z6825.1	LAMP, incandescent: 115v; 7 w; C-7 bulb, white; over-all lg 2-1/8″; candelabra screw base; Mazda #7C7/w.
TrI	I-1976A I-1977A I-1978A I-1979A	6Z6815-13	LAMP, incandescent: Mazda #50 A/RS; (115v; 50 w; A-19 bulb, inside frosted; G-22 fil; med screw base; rough service).
CP	I-1754	2Z5883-79	LAMP ASSEMBLY: pilot light; GE dwg #M7465291-G1 (cap dimen 7/8″ diam; extends 0.787″ beyond cup; cup dimen 15/16″ diam; over-all lg 1.974″ amber cap; 2 lugs 90° apart, holes in lugs 0.081″; #46 for Mazda #44, 250A, 6-8v bayonet base).
ATU RU R RaR ReR PPR CP LO ARU	I-501 I-601 I-701 I-801 I-802 I-1001 I-1501 I-1753 I-1801 I-2101	2Z5883-48.1	LAMP ASSEMBLY: pilot; GE dwg ML-#7465291G2 (panel mtg for Mazda #44 or 47 w/red translucent cap; 0.150 amp; 1.975″ h x 1.312″ w/over-all; 2 mtg holes 0.116″ diam on 1″ centers; cap 7/8″ diam, removable to enable substitution of colors; similar to 2Z5883-48, except includes cap).
DP	I-1901	2Z5884-40	LAMP ASSEMBLY: Bryant Elec #388; GE dwg #7886850P1; (holder; candelabra screw base; porcelain body 1″ diam; 2 holes in bushing tapped for #5-40 mtg screws; mtg/c 1-3/16″; over-all diam 1-9/16 x 1-13/32″).

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
CP	I-1751	2Z5883-70	LAMP, socket assembly: GE #M-7465291G3; (consisting of green plastic cap to cover Mazda #44 lamp and socket; 1.974″ h x 1.312″, wd over-all; cap diam 7/8″; miniature bayonet type having 2 mtg holes for #4-40 mach screws; mounts in back of panel; socket material black hard rubber).
CP	I-1752	2Z5883-72	LAMP, socket assembly: miniature bayonet type GE #7465291G (consisting of white urea plastic cap to cover Mazda #44 lamp and socket; 2 mtg holes for #4-40 mach screws; mounts in back of panel; socket black hard rubber).
TrL	I-1976 I-1977 I-1978 I-1979	6Z8355-10	LAMPHOLDER: porcelain; 1-1/4″ thk, 4-3/8″ lg 1-1/2″ wd; Bryant Elec cat #1708; 660 w; 250v; two 1/4″ diam mtg holes on 4-1/8″ mtg; push switch.
PI	I-1201 thru I-1206	2Z25883-218	LAMPHOLDER: miniature bayonet base; spring steel; 1-1/4″ lg x 7/8″ diam; Wemco dwg #7408931-G1
ACR		2Z5882-4	LAMPHOLDER: pilot light; ceramic; miniature screw base; over-all size 2-1/32″ lg x 1-5/16″ wd x 15/16″ thk; GE M-7465291-GRCO #2.
DUA	X-1491	2Z5883-104	LAMPHOLDER, pilot light: miniature bayonet base; clip on bracket; socket 1/2″ x 1″ h; Amer Red Hdwe type #Z-160-2.
ACCU	X-1407 X-1408	2Z5884-48	LAMPHOLDER, pilot light: Navy type E, dwg #9S-2036L; WE dwg #D-151667, part 75; std candelabra screw base; 1-9/16″ lg w/1″ flange x 1-1/8″ h over-all.
RI	I-901	2Z5883-218	LAMPHOLDER: socket; miniature base; cr steel cadmium pl; over-all dimen 1-1/4″ lg x 7/8″ h x 7/16″ wd; Cinch #3175 w/#1393-B mtg base; Wemco dwg 7614137, part 166.
		2Z4384-28	LINE, RF transmission: coaxial; rigid; characteristic impedance 51 ohms; air dielectric; LH Terpening M nut assembly part/dwg B-270-143-1; Wemco dwg #7417191, part 1.
		2Z10008-81	LINE, RF transmission; coaxial; rigid "L" section; characteristic impedance 51 ohms; single solid copper conductor 5/16″; air center cond or stud supported; LH Terpening "section x (AB)" dwg B-400-30; Wemco dwg #741791, part 3, item 1.
		2Z10008-83	LINE, transmission: coaxial; rigid; characteristic impedance 51 ohms; single solid copper conductor 7/16″; air Dielectric center cond "stud supported" LH Terpening "section x (B-C)" dwg B-270-243; Wemco dwg #7417191, part 4, item 1.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
		2Z10008-80	LINE, RF transmission: coaxial; rigid; characteristic impedance 51 ohms; air dielectric center cond stud supported; LH Terpening pre-plumb assg less "M" nut part/dwg B-270-143-2; Wemco dwg #7502956, part 2.
M DP	F-201 F-202 F-1901 thru F-1909	3Z3025	LINK, fuse: 25 amp; 250v; Fed spec W-F-803; type II, renewal link for 3Z2625.1.
		6L70010-6	LOCKWASHER: #10; split ring; phosphorus bronze; 0.200″ ID x 0.325″ OD x 3/64″ thk.
		2Z6390-12	MAGNET, adjustable: OSC; calibrated to 2,200 gauss; approx over-all dimen 7-7/8″ h x 5″ wd x 11″; GE dwg ML 7765115 G-1.
R	M-701	3F891-40	METER, ammeter: DC; O-1 ma; D'Arsonval movement; accuracy 2%; calibrated for 1/8″ steel panel; Wemco type # PX-35; # S-1159687.
ATU	M-501	3F901E5-9	METER, ammeter: DC; O-15 ma; flush mtg; textolite case; flange 3-1/8″ x 2-63/64″; GE # DO-53; cat. 93 x 93 dwg # P-7764612, part 7; accuracy 2%; D'Arsonval movement; calibrated for 1/8″ steel panel; 1/4″-28 studs on 1-3/16″ centers; 4 # 6-32 tapped mtg holes on 2-1/4″ centers; self-contained; moisture-proofed.
M CP	M-201 M-1752	3F905-30	METER, ammeter: O-50 ma; flush mtg; textolite case; flange 3-1/8″ x 2-63/64″; body 2.8″ diam x 1-35/64″ d; GE # DO-53; cat. 93 x 96 dwg # P-7764612P; accuracy 2%; D'Arsonval movement; calibrated for 1/8″ steel panel; 1/4″-28 studs on 1-3/16″ centers; 4 # 6-32 tap holes on 2-1/4″ centers; self-contained; moistureproofed.
AETU	M-401 M-402	3F905-31	METER, ammeter: DC; O-50 ma; scale; 0-5v full scale deflection; flush mtg; textolite case; flange 3-1/8″ x 2-63/64″; body 2.8″ diam x 1-35/64″ d; GE # DO-53; dwg # P-7764612, part 6; accuracy 2%; D'Arsonval movement; calibrated for 1/8″ steel panel; 1/4″-28 studs on 1-3/16″ center; 4 # 6-32 tapped mtg holes on 2-1/4″ centers; self-contained; moistureproofed.
CP	M-1754	3F3373-2	METER, milliammeter: DC; 1 ma; rectangular; flush mtd; 2-3/4″ body diam; 3″ x 3-1/8″ front flange; Wemco type # RX-35 similar to S# 1159687 except scale to be calibrated 0-10,000 yds; Wemco dwg # T-7614139, part 300.
CP	M-1753	3F13999-10	METER, milliammeter: DC; 2 ma; rectangular; flush mtd; 2-3/4″ body diam; 3″ x 3-1/18″ front flange; Wemco type # RX-35 similar to S# 1159689 except scale to be calibrated 0-25 kv DC; Wemco dwg # T-7614139, part 299.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
CP	M-1751	3F8150-103	METER, voltmeter: AC; 25 to 200 cy; 0-150v; rectangular; flush mtd; 2-3/4″ body diam; 3″ x 3-1/8″ front flange; Wemco type #RA-35; S#1159027; Wemco dwg #T-7614139, part 297.
DUA	B-1491	3H3000-62	MOTOR, AC: induction; 55 gm torque; fractional hp; closed; 4-1/4″ lg, 2-15/16″ diam; aluminum rotor shaft w/gear 9/16″ diam; 20v; 200 cps; 2 ph; 9,000 rpm; WECo #ES-8624.
LO	B-1801	3H3000-102	MOTOR, AC: induction type; 1/2,000 hp; 115v AC; 600 cps; single phase; 0.1 amp; 1,320 rpm; Bodine type #KC-1-22RC; Wemco dwg #M-7415521, part 1.
RI	B-901 B-902	3H3100-3	MOTOR, DC: shunt wound; 1/150 hp; 3,000 rpm; 80 vdc; Lime Works dwg #9-D-5879; electrically and mechanically interchangeable w/ GE #5BN38BA10.
PCU	B-1302	3H3000-93	MOTOR, AC: induction; 1/150 hp; 5,000 rpm; Wemco part/dwg #740883, part 1; Wemco dwg #T-7614134-4.
	B-1976	3H3000AO2-19	MOTOR, AC: induction; 1/50 hp; 115v; 60 cyc; 2 phase or capacitor start single phase; Wemco dwg #7713786, part 1.
PCU	B-1303 B-1353	3H3000-22	MOTOR, AC: 20v; 0.85 amp; 60 cps; 1,600 rpm; 2 phase; GE dwg #K8276586.
M	B-201	3H3000-101	MOTOR, synchronous: induction type; Superior Elec #DP3006C-2 (drive motor T-201).
TrL		2Z8406-9	MOUNT: shock; plate-holder; 112 rated loading in lbs; 3″ x 3″; four mtg holes size 0.257″ spaced 2-1/2″ apart; Lord Mfg Co type #204 PH-112; metal parts cold rolled steel, plates square, wax-treated for shipment, metal parts in square cannot be pl; holder cadmium-pl w/load sides reversed.
M		2Z8407-7	MOUNT: shock; square; 220 lbs load rating w/3/16″ deflecting under load; 3-1/4″ x 3-1/4″ (1750″ diam); four mtg holes size 0.328″, equally spaced 2-9/16″ apart; Lord Mfg Co cat. #281P-220; cold rolled steel; plates square, wax-treated for shipment; metal plates not pl.
TrL		2Z8406-7	MOUNT: shock; square; 75 lbs load rating w/1/8″ deflection under load; 2-1/4″ x 2-1/4″ x 1″; four mtg holes size 0.196″ equally spaced 1-3/4″ apart; Lord Mfg Co #204P-75; cold rolled steel, plates square, wax-treated for shipment; metal plates are not pl.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
TrL		2Z8406-8	MOUNT: shock; plate-holder; 112 rated loading in lbs; 3″ x 3″; four mtg holes size 0.257″, spaced 2-1/2″ apart; Lord Mfg Co type #204PH-112; metal parts cold rolled steel; plates square, wax-treated for shipment; metal parts in square cannot be pl; holder cadmium-pl.
		2Z8406-3	MOUNT, vibration: round rubber on CRS base; 120 lb load rating; 3″ lg x 2-5/16″ h; Lord Mfg Co S#200xPH60; Wemco dwg #7416899, part 14.
ACCU	Z-1401	2Z6840-26	NETWORK: filter, 10 hy; toroidal coil; 2 capacitors, 440,000 mmf; ±10%; 400 vdcw; WECo D-163993; WECo dwg #D-164758.
ACCU	Z-1402	2Z6840-25	NETWORK: stabilizing; 390 ohms, 250 cycles; 2 toroidal type coils; 2 capacitors, 20,000 mmf; WECo type 402C, one 20,000 mmf capacitor; WECo dwg 234A; WECo dwg D-164759.
		6L3504-28.5	NUT, thin, hex: steel; 1/4″-28 thd per in; 5/32″ thk; 7/16″ dist across flat; Palmer-Bee Co, RI 108-009-C; Wemco dwg #M-7417540, part 5.
		2C2780-1374	OSCILLATOR BC-1374: (local).
		2C5066-1056C	RADIO RECEIVER BC-1056-C: (demodulator) Wemco #DL-7502457-G2.
		2C6996-1062C	RANGE UNIT BC-1062-C: with crystals, Wemco #7502456-G2.
		2C1557-1371	RANGE INDICATOR BC-1371: Wemco #DL-7502459-G2.
		3H4996-14	REGULATOR TF-14: (line) Wemco #DL-7502974-G1.
		3H4691-66A 3H469-66	RECTIFIER RA-66-A: (receiver) Wemco #DL-7502460-G2.
DP	CR-1901 CR-1902	3H4859-3	RECTIFIER, selenium; half-wave; Fed Tel & Rad #2H12C1.
		3H4691-69A	RECTIFIER RA-69-A: (plan position power) Wemco #DL-7502465-G2.
		3H4691-70A	RECTIFIER RA-70-A: (altitude converter power unit) Wemco #DL-7502464-G2.
M		3H4691-71A	RECTIFIER RA-71-A: (field).
		3H4691-72A	RECTIFIER RA-72-A: (range power) Wemco #DL-7502458-G2.
ACCU	K-1401	2Z7588-65	RELAY, double transfer: DPDT; 6.3v AC; 60 cy; 6-1/2″ w; 98 ohms; 3-3/8″ lg x 2-1/8″ wd x 2-7/16″ h; WECo #KS8690.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
M	K-202 K-204	2Z7593-8	RELAY: 115v AC; 3 pole; Dunco #8CXX; normally open; 8 term; silver cont; 30 amp, 115v DC; 4 amp; bakelite insulation; coil; 115v 60 cps; 0.140 amp; 1,437 ohm impedance; dimen 4-1/4″ lg x 3″ wd x 2-7/8″ h; mtg 4 #8 holes; 2 fronts on 1-1/8″ centers; 2 back on 2-3/8″ centers; Redtel & Rad.
M	K-205	2Z7586-78	RELAY: SPST, normally open circuit, closes at end of 30 sec; reset when motor is disconnected; 4″ lg x 3″ wd over-all; Wemco dwg #P-7710009; two stud bolts mtg 1-2/22″ mtg centers.
M	K-203 K-207	2Z7599-69	RELAY: SPST, normally open; 2-5/8″ lg x 1-1/2″ wd x 1-1/4″ h over-all; Clare CP type B-7735; 1/8″ armature end slug; 2,200 ohms, 16,000 turns #39EC; 13 #8-32 holes 3/4″ mtg centers.
M	K-206	2Z7590-107	RELAY: discharge switch; normally open; 8-3/32″ lg x 3-1/2″ h x 1-1/2″ wd over-all; Wemco dwg #7713839G-1; 1/2″ silver cont; cont rating 115v AC; 60 cys; multiple wound, 115v AC; 15.60 ohms at 0.95 amps intermittent; 115v AC; 31.2 ohms at 0.39 amp continuous; bracket mtg, stand-off 1-5/32″ from bakelite base 1/4″ diam hole.
DU	K-101	2Z7599-35	RELAY: sensitive; SPDT; GE dwg #N7467733, part 1; GE type CR2791-C103C32; 40 mw coil; 108 ohm; pickup 20 ma, drop out 7.5 ma to 17 ma; metal case; bakelite; base; 5 pins 0.125″ diam extending 0.562 in circle 0.750″ diam; over-all dimen 1.875″ diam, 2.655″ h.
M	K-201	3H5310-13	RELAY: 3 phases; 115v; 1 normally open cont; Wemco #9726970; Wemco part/dwg #T-7614138, part 228.
ATU R CP	K-501 K-502 K-701 K-1751	3C1108-8	RELAY: 6 amp cont; coil 115v; 60 cyc; DPDT; Leach Relay #1127BF; Wemco part/dwg #T-7614138, part 225.
PI	K-1201 K-1202	2Z7593-41	RELAY: switching; 22 cont; 4 pole DT; Clare CP type A, GE dwg #K8276427, part 1; w/3 extra NC cont; solenoid type; 14 NC cont; 8 NC cont; material of cont is paladium and elkonium; coil operates on 115v AC; 60 cps; over-all dimen 4″ lg x 2-3/8″ h x 1-5/8″ thk; mtg by 2 #6-32 screw, 5 on 3/4″ centers.
AETU	K-401 K-402	2Z7596-3	RELAY: switching; 10 cont SPDT; Clare CP type A; GE dwg #K8276496; solenoid; 5 open cont; 5 closed and continuous; cont 9, 10, 11 are elkonium; all others are palladium; 150 w; 3 amp; 115v; 60 cyc continuous; double insulation, 9/16″ wafers between cont and insulation, over-all dimen 8-3/16″ x 3-7/8″ x 2-3/16″ h; 3 mtg holes (2 on 3-1/8″ centers, 1 centered) ref K1-K2.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
PI	R-1201	3Z5991-32	RESISTOR, fixed: WW; 1.5 ohms ±10%; 10 w; IRC #AB (cement coated; 1-3/4″ lg x 5/16″ diam; #2 solder lug terms).
DUA	R-1489	3Z5995-23	RESISTOR, fixed: WW; 5 ohms ±5%; 10 w.
ATU RU R RaR ReR ACR PPR PPI LO ARU	R-507 R-693 R-745 R-801 R-819 R-1004 R-1473 R-1511 R-1701 R-1702 R-1703 R-1801 R-2188	3Z6001-18	RESISTOR, fixed: WW; 10 ohms ±10%; 1 w; IRC #BW-1; (insulated; 1-1/4″ lg x 1/4″ diam; ref 131-1 & 131-2).
DU	R-118 R-119 R-124 R-125	3Z6001-41	RESISTOR, fixed: WW; 10 ohms ±5%; 5 w; Sprague Koolohm #5W1; (ceramic insulation; noninductive; 1-7/32″ lg x 7/16″ diam; 2-1/2″ axial wire leads).
M	R-210 R-211	3Z6001-102	RESISTOR, fixed: ceramic 10 ohms ±15%, 6 w; 3″ lg x 3/4″ diam; Carborundum type A, "G" dipped coating; Wemco dwg #T-7614143, part 456.
PPU	R-1681 R-1683	3Z6001B2-11	RESISTOR, fixed: WW ins; 12 ohms ±10%, 2 w; 1-3/4″ lg x 5/16″ OD; IRC; BW-2; Wemco dwg #T-7614144, part 506.
PPU	R-1642	3Z6001B8-15	RESISTOR, fixed: WW, 18 ohms ±2%, 5 w; 1″ lg x 5/16″ diam; Ohmite term type 48; Wemco dwg #7614143, part 493.
DU	R-122 R-123	3RC30BE220K	RESISTOR, fixed: carbon; 22 ohms ±10%; 1 w; AB type GB.
PPU	R-1643	3Z6003C3-15	RESISTOR, fixed: WW, 33 ohms ±2%, 5 w; 1″ lg x 5/16″ diam; Ohmite term type 48; Wemco dwg #7614143, part 494.
RVA ARR	R-1126 R-1851 R-1852 R-1860 R-2206 R-2207 R-2208 R-2209	3Z6004A7-2	RESISTOR, fixed: composition; 47 ohms ±10%; 1/2 w; IRC #BT-1/2.
DU	R-111 R-112 R-116 R-117 R-120	3Z6004A7-16	RESISTOR, fixed: WW; 47 ohms ±10%; 1 w; IRC #BW-1; (phenolic insulation; cylindrical; 1/4″ diam x 1-1/4″ lg w/axial wire leads 0.32″ diam x 1-1/2″ lg at each end).

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
 M ACR	R-121 R-213 R-214 R-1484 R-1485		
PPU	R-1675 R-1690	3Z6004A7-19	RESISTOR, fixed: WW; 47 ohms ±10%; 2w; IRC # BW-2; (insulated; 1-3/4″ x 5/16″ diam; axial leads).
PPU	R-1640 R-1641	3Z6005-144	RESISTOR, fixed: WW; 50 ohms ±2%; 5 w; 1″ lg x 5/16″ diam; Ohmite term type 48; Wemco dwg # 7614143, part 492.
DU R M	R-113 R-114 R-208 R-209	3Z6005-73	RESISTOR, fixed: WW; 50 ohms ±5%; 5 w; Sprague Koolohm # 5W1; (ceramic insulation; noninductive 1-7/32″ lg x 7/16″ diam; 2-1/2″ axial wire leads).
R	R-711 R-754 R-755	3RC30BE560K	RESISTOR, fixed: composition; 56 ohms ±10%; 1/2 w; AB type EB.
		3Z6006-30	RESISTOR, fixed: WW; 60 ohms; 25 w; 5/16″ ID x 9/16″ OD x 2″ lg; Wemco Lima dwg 8-D-2693, item 4; Wemco dwg # 7411001, part 4.
R RVA	R-701 R-1101	3RC20BE750J	RESISTOR, fixed: composition; 75 ohms ±5%; 1/2 w; AB type EB.
ACCU	R-1447 R-1458	3Z6010-59	RESISTOR, fixed: WW; 100 ohms ±5%; 1/2 w; IRC type BW-1/2.
R RVA PA	R-708 R-714 R-729 R-744 R-759 R-1108 R-1855 R-1858 R-1859 R-1861	3RC20BE101K	RESISTOR, fixed: composition; 100 ohms ± 10%; 1/2 w; AB type EB.
PPU	R-1667 R-1680	3Z6010-23	RESISTOR, fixed: WW; 100 ohms ±10%; 2 w; IRC # BM-2.
AETU	R-425 R-426 R-475 R-476	3Z6010-176	RESISTOR, fixed: WW; single element; 10 ±2%; 5 w; 1″ lg x 5/16″ diam; Ohmite term type 48; Wemco dwg # 7614142, part 407.
M	R-201 R-202	3Z6010-164	RESISTOR, adjustable: WW; 100 ohms; 13 w; 6″ lg x 3/4″ diam; metalized ends; Carborundum # 37.
R PA	R-702 R-705 R-1853 R-1856	3RC20BE121K	RESISTOR, fixed: composition; 120 ohms ± 10%; 1/2 w; AB type EB.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
RU	R-633	3Z6015-21	RESISTOR, fixed: WW; 150 ohms ±10%; 1/2 w; IRC type BW-1/2; (insulated; 5/8″ lg x 3/16″ diam; axial leads 1-1/2″ lg; ref 428).
RVA	R-1102	3RC20BE151K	RESISTOR, fixed: composition; 150 ohms ± 10%; 1/2 w; AB type EB.
OPS ARU	R-971 R-2108 R-2109 R-2110	3RC21BE181K	RESISTOR, fixed: composition; 180 ohms ± 10%; 1/2 w; IRC #BT-1/2 (5/8″ lg x 3/16″ diam; metalized fil or an insulated base of a glass tube).
PPU	R-1673 R-1677 R-1678 R-1685	3Z6020-10	RESISTOR, fixed: WW; 200 ohms ±5%; 2 w; IRC #BW-2 (insulated; 1-3/4″ lg x 5/16″ diam).
R RVA PA R	R-704 R-707 R-710 R-713 R-716 R-719 R-722 R-731 R-750 R-1105 R-1862	3RC20BE271K	RESISTOR, fixed: composition; 270 ohms ± 10%; 1/2 w; AB type EB.
ACCU ACR	R-1456 R-1483	3Z6030-93	RESISTOR, fixed: WW; 300 ohms ±10%; 4 w.
M	R-224	3Z603025	RESISTOR, fixed: power WW; cement coated; 365 ohms ±5%; 25 w; IRC type DH (9/16″ diam x 2-1/2″ lg, noninductive; salt water immersion test; term soldering lugs; horizontal mtg brackets).
PCU	R-1301	3Z6033-16	RESISTOR, fixed: WW; 330 ohms ±10%; 50 w; (cement coated; 8″ lg x 3/4″ diam; solder lugs).
RV R OPS ARR	R-602 R-723 R-974 R-2210 R-2211 R-2212 R-2213	3RC21BE471K	RESISTOR, fixed: composition; 470 ohms ± 10%; 1/2 w; IRC #BT-1/2.
AGR	R-1486 R-1487	3RC21BF471E	RESISTOR, fixed: composition; 470 ohms ± 10%; 1/2 w.
DU	R-138	3Z6050-102	RESISTOR, fixed: WW; 500 ohms ±5%; 10 w; Sprague Kooluhm #LC5L; (ceramic insulation; 1-25/32″ lg x 7/16″ diam; axial wire leads 2-1/2″ lg).

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
ARU	R-2157 R-2158 R-2159 R-2160	3RC21BE511J	RESISTOR, fixed: composition; 510 ohms ±5%; 1/2 w; IRC type BT-1/2.
ARU	R-2164	3RC31BE511J	RESISTOR, fixed: composition; 510 ohms ± 5%; 1 w; IRC # BT-1.
RVA	R-1116 R-1117 R-1118	3RC41BE511J	RESISTOR, fixed: composition; 510 ohms ± 5%; 2 w; IRC # BT-2.
ARU	R-2103	3RC21BE561K	RESISTOR, fixed: composition; 560 ohms ± 10%; 1/2 w; IRC # BT-1/2.
ACCU	R-1446	3RC21BF751J	RESISTOR, fixed: composition; 750 ohms ± 5%; 1/2 w.
ACR	R-1481 R-1482	3Z6075-50	RESISTOR, fixed: WW; 750 ohms ±10%; 4 w.
PPU LO	R-1687 R-1826	3RC31BE821K	RESISTOR, fixed: composition; 820 ohms ± 10%; 1 w; IRC # BT-1.
R RVA	R-703 R-706 R-709 R-756 R-1104	3RC21BE821J	RESISTOR, fixed: composition; 820 ohms ± 5%; 1/2 w; IRC # BT-1/2.
ARU	R-2161	3RC41BE821K	RESISTOR, fixed: composition; 820 ohms ± 10%; 2 w; IRC # BT-2.
ACCU ACR	R-1451 R-1474	3RC21BF911J	RESISTOR, fixed: composition; 910 ohms ±5%; 1/2 w.
RU R SD OPS PPU PA	R-634A R-725 R-730 R-925 R-925A R-940 R-941 R-959 R-962 R-963 R-965 R-1636 R-1646 R-1854	3RC21BE102K	RESISTOR, fixed: composition; 1,000 ohms ± 10%; 1/2 w; IRC # BT-1/2.
ACCU	R-1414 R-1419 R-1429 R-1437	3RC21BF102K	RESISTOR, fixed: composition; 1,000 ohms ± 10%; 1/2 w.
RU PPU	R-618 R-1654	3RC31BE102K	RESISTOR, fixed: composition; 1,000 ohms ± 10%; 1 w; IRC # BT-1.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
ARU	R-2176	3RC41BF102K	RESISTOR, fixed: metallized fil ins; 1,000 ohms ±10%; 2 w; 5/16" diam x 1-3/4" lg; IRC #BT-2; Wemco dwg #T-7614146, part 605.
PPU	R-1602	3Z6100-136	RESISTOR, fixed: WW; 1,000 ohms ±5%; 10 w; IRC #DH; (cement coated; 2-1/2" lg x 9/16" diam; solder lugs).
R RVA ARU	R-732 R-1121 R-2153	3Z6120-2	RESISTOR, fixed: 1,200 ohms ±10%; 1 w; IRC #BT-1 (insulated 1-1/4" lg x 1/4" diam; ref 14 for I-108 of #RC-68-A).
AETU	R-417 R-467	3Z6120-18	RESISTOR, fixed: WW; 1,200 ohms ±5%; 2 w; IRC #DG; (cement coated; inductive; 2" lg x 9/16" diam; solder lugs).
RU R ARU	R-661 R-712 R-715 R-2154	3RC21BK152K	RESISTOR, fixed: composition; 1,500 ohms ± 10%; 1/2 w; IRC #BT-1/2.
OPS PA	R-966 R-969 E-1857	3RC20BE152K	RESISTOR, fixed: composition; 1,500 ohms ± 10%; 1/2 w; AB #EB.
RU PPU	R-680 R-1655	3RC31BE152K	RESISTOR, fixed: composition; 1,500 ohms ± 10%; 1 w; IRC #BT-1.
RU R	R-647 thru R-651 R-664 thru R-668 R-720	3RC41BE152K	RESISTOR, fixed: composition; 1,500 ohms ± 10%; 2 w; IRC #BT-2.
ARU	R-2113 R-2114	3RC21BE202J	RESISTOR, fixed: composition; 2,000 ohms ± 5%; 1/2 w; IRC #BT-1/2.
AETU	R-416	3RC31BF202J	RESISTOR, fixed; metalized fil ins; 2,000 ohms ±5%; 1 w; 1/4" diam x 1-1/4" lg; IRC, #BT-1; Wemco dwg #T-7614142, part 401.
ARU	R-2155	3RC41BE202J	RESISTOR, fixed: composition; 2,000 ohms ± 5%; 2 w; 1.78" lg x 0.342" diam; IRC type #BT-2; Wemco dwg #T-7614144-523.
R	R-760	3RC21BE222K	RESISTOR, fixed: composition; 2,200 ohms ± 10%; 1/2 w; IRC #BT-1/2.
DU M	R-137 R-235 R-236	3RC31BE222K	RESISTOR, fixed: composition; 2,200 ohms ± 10%; 1 w; IRC #BT-1.
PPU ARU	R-1616 R-2150 R-2151	3RC41BE222K	RESISTOR, fixed: composition; 2,200 ohms ± 10%; 2 w; IRC #BT-2.
RVA	R-1124	3RC21BE242J	RESISTOR, fixed: composition; 2,400 ohms ± 5%; 1/2 w; IRC #BT-1/2.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
RU RVA	R-644 R-675 R-1112	3RC21BE272J	RESISTOR, fixed: composition; 2,700 ohms ± 5%; 1/2 w; IRC #BT-1/2.
RU	R-640 R-697	3RC31BE272K	RESISTOR, fixed: composition; 2,700 ohms ± 10%; 2 w; IRC #BT-2.
ACR	R-1477	3RC21BF302J	RESISTOR, fixed: composition; 3,000 ohms ± 5%; 1/2 w.
AETU	R-469	3RC31BE302J	RESISTOR, fixed: composition; 3,000 ohms ± 5%; 1 w; IRC #BT-1.
ARU	R-2148	3RC41BE302J	RESISTOR, fixed: composition; 3,000 ohms ± 5%; 2 w; IRC #BT-2.
RVA ARU	R-1106 R-2115	3RC21BE332K	RESISTOR, fixed: composition; 3,300 ohms ± 10%; 1/2 w; IRC #BT-1/2.
R	R-721	3RC41BE332K	RESISTOR, fixed: composition; 3,300 ohms ± 10%; 2 w; IRC #BT-2.
R	R-747	3Z6350-23	RESISTOR, fixed: WW; 3,500 ohms ±5%; 10 w; IRC #DH.
DU RU RaR PPU	R-136 R-635 R-637 R-803 R-1601	3RC31BE392J	RESISTOR, fixed: composition; 3,900 ohms ± 5%; 1 w; IRC #BT-1.
RU LO ARR	R-652 R-669 R-1802 R-1803 R-1804 R-1805 R-2217	3RC41BE392K	RESISTOR, fixed: composition; 3,900 ohms ± 10%; 2 w; IRC #BT-2.
DU	R-127	3Z6400-44	RESISTOR, fixed: WW; 4,000 ohms ±5%; 50 w; Sprague Koolohm #50N1.
R	R-746	3RC21BE472K	RESISTOR, fixed: composition; 4,700 ohms ± 10%; 1/2; IRC #BT-1/2.
DU ARU	R-106 R-2152	3RC21BE472J	RESISTOR, fixed: composition; 4,700 ohms ± 5%; 1 w; IRC type #BT-1.
DU	R-126	3Z6500-144	RESISTOR, fixed: WW; 5,000 ohms ±5%; 50 w; Sprague Koolohm #50K; (ceramic insulation; noninductive; 4″ lg x 7/8″ diam; 2 soldering term lugs).
ATU OPS ARU	R-501 R-952 R-2116 R-2117 R-2118	3RC21BE512J	RESISTOR, fixed: composition; 5,100 ohms ± 5%; 1/2 w; IRC type #BT-1/2.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
AETU RU LO	R-434 R-484 R-631 R-691 R-692 R-1818 R-1819	3Z6501-11	RESISTOR, fixed: metalized fil ins; 5,100 ohms ±5%; 2 w; 5/16″ diam x 1-3/4″ lg IRC # BT-2; Wemco dwg # T-7614142, part 414.
ReR ARR	R-1002 R-2220	3Z6505-2	RESISTOR, fixed: WW; 5,500 ohms ±5%; 12 w; IRC # DJ; (cement coating; inductive; 3″ lg x 9/16″ diam; solder lugs).
ATU	R-502	3RC21BE562J	RESISTOR, fixed: composition; 5,600 ohms ± 5%; 1/2 w; IRC # BT-1/2.
RVA	R-1125	3RC21BF562K	RESISTOR, fixed: composition; 5,600 ohms ± 10%; 1/2 w; 5/8″ lg x 3/16″ diam; IRC type # BT-1/2; Wemco dwg # T-7614145, part 581.
RU	R-641 R-658 R-676	3RC31BE562K	RESISTOR, fixed: composition; 5,600 ohms ± 10%; 1 w; IRC # BT-1.
RU	R-642 R-659 R-677	3RC41BE562K	RESISTOR, fixed: composition; 5,600 ohms ± 10%; 2 w; IRC # BT-2.
ACCU	R-1457	3Z6560-14	RESISTOR, fixed: composition; 6,000 ohms ± 5%; 1/2 w.
ARU	R-2147	3Z6560-57	RESISTOR, fixed: power WW; 6,000 ohms ± 10%; 10 w; IRC # DH; (cement coated; 9/16″ diam x 2-1/2″ lg; noninductive, salt water immersion test; term soldering lugs; horizontal mtg brackets).
R	R-751	3RC31BE622J	RESISTOR, fixed: composition; 6,200 ohms ± 5%; 1 w; IRC # BT-1.
SD	R-943	3Z6562-6	RESISTOR, fixed: composition; 6,200 ohms; 500v; 2 w; AB # F6225; (1-31/32″ wd x 31/64″ diam; no terms; 1-1/2″ lg # 18 gauge wire leads; point to point mtg).
ARU	R-2111 R-2112	3RC31BF862J	RESISTOR, fixed: metallized fil ins; 6,800 ohms ±5%; 1 w; IRC # BT-1; Wemco dwg # T-7614142-429.
R CP	R-752 R-1754	3RC31BE682K	RESISTOR, fixed: composition; 6,800 ohms ± 10%; 1 w; IRC type # BT-1.
RVA	R-1114	3RC21BE752J	RESISTOR, fixed: composition; 7,500 ohms ± 5%; 1/2 w; IRC # BT-1/2.
RU PPU	R-681 R-1639 R-1645	3RC31BE752J	RESISTOR, fixed: composition; 7,500 ohms ± 5%; 1 w; IRC # BT-1.
RU ARU	R-682 R-2162 R-2163	3RC41BE752J	RESISTOR, fixed: composition; 7,500 ohms ± 5%; 2 w; IRC # BT-2.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
DU	R-108 R-130	3Z6580-23	RESISTOR, fixed: WW; 8,000 ohms ±5%; at 30°C; 35 w; WL # B; GE dwg # M7466291-40; (vitreous enameled; 3″ lg x 3/4″ diam x 15/32″ ID of tube; soldered lugs; # 219 term 3″ lg).
R	R-758	3RC21BF822K	RESISTOR, fixed: composition; 8,200 ohms ± 10%; 1/2 w; 0.655″ lg x 0.249″ diam; IRC type # BT-1/2; Wemco dwg # T-7614145-569.
RaR	R-815	3Z6582-11	RESISTOR, fixed: carbon; 8200 ohms ±5%; 1 w; IRC # BT-1 (insulated; 1-1/4″ lg x 1/4″ diam; axial wire leads).
DU AETU RU PPU	R-131 R-132 R-139 R-410 R-411 R-435 R-460 R-461 R-486 R-686 R-1633 R-1634 R-1635 R-1649 R-1650 R-1651	3RC41BE822J	RESISTOR, fixed: composition; 8,200 ohms ± 5%; 2 w; IRC # BT-2.
PPU	R-1637 R-1647	3RC31BE912J	RESISTOR, fixed: composition; 9,100 ohms ± 5%; 1 w; IRC # BT-1.
DUA	R-1499	3Z5907A-4	RESISTOR, fixed: WW; 9,300 ohms ±1%; 3/8 w; WECo # 107-A.
ACCU	R-1438	3Z6610-84.1	RESISTOR, fixed: WW; 10,000 ohms ±1%; 1/4 w; WECo # 107-A.
ACCU	R-1459	3Z6610-119	RESISTOR, fixed: WW; 10,000 ohms ±0.1%; 1 w; WECo # D-162746-C.
DU AETU ATU RaR RVA FS PPR PPU LO	R-105 R-422 R-472 R-511 R-804 R-1122 R-1157 R-1158 R-1159 R-1509 R-1610 R-1611 R-1618 R-1621 R-1808 thru R-1816	3RC41BE103J	RESISTOR, fixed: composition; 10,000 ohms ± 5%; 2 w; IRC # BT-2.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
R PPU	R-718 R-1668	3Z6610-141	RESISTOR, fixed: WW; 10,000 ohms ±5%; 10 w; IRC #DH (ceramic core cement coating; 2-1/2" lg x 9/16" diam solder lugs).
R	R-737	3Z6610-142	RESISTOR, fixed: WW; C coating; 10,000 ohms ±5%; 12 w; not tapped; 3" lg x 9/16" OD x 3/8" ID; IRC type #DJ; Wemco dwg #T-7614145-563.
M	R-212 R-216 R-217	3Z6610	RESISTOR, fixed: WW; 10,000 ohms ±5%; 120 w; similar to US Navy Grade #1 class #1 style A; (ceramic; inductive; metal ferrule on each end of resistor).
DU RU RVA ARU	R-128 R-685 R-1113 R-2101 R-2102 R-2105 R-2106	3RC21BE103J	RESISTOR, fixed: composition; 10,000 ohms ±5%; 1/2 w; IRC #BT-1/2.
RaR OPS PPU TrL	R-814 R-954 R-955 R-972 R-1626 R-1627 R-1629 R-1755 R-1756	3RC31BE103J	RESISTOR, fixea. composition; 10,000 ohms ±5%; 1 w; IRC #BT-1.
AETU	R-427 thru R-430 R-477 thru R-480	3Z6610-178	RESISTOR, fixed: precision; WW; 10,000 ohms ±1%; 1 w; 29/64" OD x 3/4" lg x 7/32" ID; IRC; WW7; Wemco dwg #T-7614142, part 408.
ACR	R-1479	3RC31BF103K	RESISTOR, fixed: composition; 10,000 ohms ±10%; 1 w.
ATU	R-515 R-517	3RC21BE113J	RESISTOR, fixed: composition; 11,000 ohms ±5%; 1/2 w; IRC #BT-1/2.
PPU	R-1613 R-1617	3RC41BE113J	RESISTOR, fixed: composition; 11,000 ohms ±5%; 2 w; IRC #BT-2.
ARU	R-2167	3RC21BE123J	RESISTOR, fixed: composition; 12,000 ohms ±5%; 1/2 w; IRC #BT-1/2.
RVA	R-1111	3RC41BE123K	RESISTOR, fixed: composition; 12,000 ohms ±10%; 2 w; IRC #BT-2.
ReR	R-1003	3Z6612-34	RESISTOR, fixed: WW; 12,000 ohms ±5%; 16 w; IRC #EN; (cement coating 3-1/2" lg x 3/4" diam solder lugs).
ARU	R-2146	3RC41BF133J	RESISTOR, fixed: composition; 13,000 ohms ±5%; 5/8" lg x 3/16" diam; metalized fil ins.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
ACCU	R-1452	3Z6615-44.1	RESISTOR, fixed: WW; 15,000 ohms ±1%; 1/4 w; Wemco # 106-A.
RU PPR ARU	R-615 R-1508 R-2169 R-2170	3RC21BE153J	RESISTOR, fixed: composition; 15,000 ohms ±5%; 1/2 w; IRC # BT-1/2.
DU ATU	R-103 R-503	3RC31BF153J	RESISTOR, fixed: metallized fil ins; 15,000 ohms ±5%; 1 w; 1/4" diam x 1-1/4" lg; IRC BT-1; Wemco dwg # T-7614145, part 370.
PPR	R-1510	3RC41BE153K	RESISTOR, fixed: composition; 15,000 ohms ±10%; 2 w; IRC # BT-2.
R	R-735	3RC41BE183K	RESISTOR, fixed: composition; 18,000 ohms ±10%; 2 w; IRC # BT-2.
ACCU	R-1416 R-1418 R-1424	3Z6619-2	RESISTOR, fixed: composition; 19,000 ohms ±5%; 1/2 w; IRC # BT-1/2.
AETU RVA	R-405 R-406 R-455 R-456 R-1120	3RC31BE203J	RESISTOR, fixed: composition; 20,000 ohms ±5%; 1 w; IRC # BT-1.
ATU ARR	R-518 R-2218 R-2219	3RC41BE203J	RESISTOR, fixed: composition; 20,000 ohms ±5%; 2 w; IRC # BT-2.
RU	R-605 R-606 R-609 R-610 R-613 R-614 R-2107	3RC31BE223K	RESISTOR, fixed: composition; 22,000 ohms ±10%; 1 w; IRC # BT-1.
RI	R-956	3Z6617-10	RESISTOR: WW; single winding; 1,700 ohms ±1%; 1/2 w; 1/2" diam x 5/8" lg; Shallcross Mfg Co type 180.
RaR RVA PPU ARU	R-820 R-821 R-822 R-960 R-1103 R-1619 R-1620 R-1757 R-2156	3RC41BE223K	RESISTOR, fixed: composition; 22,000 ohms ±10%; 2 w; IRC # BT-2.
RU	R-654 R-671	3RC21BE243J	RESISTOR, fixed: composition; 24,000 ohms ±5%; 1/2 w; IRC # BT-1/2.
ATU	R-523	3RC31BE243J	RESISTOR, fixed: composition; 24,000 ohms ±5%; 1 w; IRC # BT-1.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
AETU	R-413	3Z6625-79	RESISTOR, fixed: WW; 25,000 ohms ±5%; 18 w; IRC #DK; (cement coating; 5" lg x 9/16" diam).
ACCU	R-1422	3RC21BF273J	RESISTOR, fixed: composition; 27,000 ohms ±5%, 1/2 w.
RU PPU	R-611 R-639 R-679 R-1615 R-1628 R-1656 R-1657	3RC21BE273K	RESISTOR, fixed: composition; 27,000 ohms ±10%; 1/2 w; IRC #BT-1/2.
RI ARU	R-912 R-913 R-2119 R-2120 R-2121	3RC21BE274K	RESISTOR, fixed: composition; 27,000 ohms ±10%; 1/2 w; IRC #BT-1/2.
DU	R-110	3RC31BE273K	RESISTOR, fixed: composition; 27,000 ohms ±10%; 1 w; IRC #BT-1.
DU RVA PPU LO ARR	R-135 R-1109 R-1606 R-1607 R-1807 R-1820 R-1821 R-2201 R-2202 R-2203	3RC41BE273K	RESISTOR, fixed: composition; 27,000 ohms ±10%; 2 w; IRC #BT-2.
ARU	R-2168 R-2174	3RC21BE303J	RESISTOR, fixed: composition; 30,000 ohms ±5%; 1/2 w; IRC #BT-1/2.
ACCU	R-1421	3RC21BF333J	RESISTOR, fixed: composition; 33,000 ohms ±5%; 1/2 w.
RU R	R-689 R-748	3RC21BE333K	RESISTOR, fixed: composition; 33,000 ohms ±10%; 1/2 w; IRC #BT-1/2.
RVA	R-1115	3RC30BE333J	RESISTOR, fixed: composition; 33,000 ohms ±5%; 1 w; IRC #BT-1.
ARR	R-2216	3RC31BE333K	RESISTOR, fixed: composition; 33,000 ohms ±10%; 1 w; IRC #BT-1.
RVA PPR PPU	R-1119 R-1529 R-1530 R-1531 R-1660 R-1661 R-1662	3RC41BE333K	RESISTOR, fixed: composition; 33,000 ohms ±10%; 2 w; IRC #BT-2.
ARU	R-2171	3RC21BE363J	RESISTOR, fixed: composition; 36,000 ohms ±5%; 1/2 w; IRC #BT-1/2.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
OPS	R-973	3RC20BE393K	RESISTOR, fixed: composition; 39,000 ohms ±10%; 1/2 w; AB #EB #3931; (3/8" wd x 9/64" diam; bakelite; no terms; 1-1/2" lg #20 gauge wire leads; point to point mtg).
SD	R-944	3RC21BE393K	RESISTOR, fixed: composition; 39,000 ohms ±10%; 1/2 w; IRC #BT-1/2.
RaR ARU	R-806 R-2143 R-2144 R-2145	3RC31BE393K	RESISTOR, fixed: composition; 39,000 ohms ±10%; 1 w; IRC #BT-1.
ATU RaR	R-512 R-513 R-818 R-823	3RC41BE393J	RESISTOR, fixed: metallized, fil ins; 39,000 ohms ±5%; 2 w; 5/16" diam x 1-3/4" lg; IRC #BT-2; Wemco dwg #T-7614141, part 375.
M	R-207	3Z6640-2	RESISTOR, fixed: carbon; 40,000 ohms ±10%; 1 w; IRC #BT-1.
ARU	R-2172	3RC21BE433J	RESISTOR, fixed: composition; 43,000 ohms ±5%; 1/2 w; IRC #BT-1/2.
RU ARU	R-604 R-606 R-612 R-672 R-3150	3RC21BE473J	RESISTOR, fixed: composition; 47,000 ohms ±5%; 1/2 w; IRC #BT-1/2.
DU RU RaR PPU	R-107 R-109 R-632 R-816 R-817 R-1676 R-1686 R-1688 R-1689	3RC31BE473K	RESISTOR, fixed: composition; 47,000 ohms ±10%; 1 w; IRC #BT-1.
ATU ARU	R-509 R-510 R-2186 R-2187	3RC21BE513J	RESISTOR, fixed: composition; 51,000 ohms ±5%; 1/2 w; IRC #BT-1/2.
ATU	R-519 R-520	3RC31BE513J	RESISTOR, fixed: composition; 51,000 ohms ±5%; 1 w; IRC #BT-1.
ACCU	R-1408	3RC31BF513J	RESISTOR, fixed: composition; 51,000 ohms ±5%; 1 w.
ACCU	R-1461 R-1466	3RC41BF513J	RESISTOR, fixed: composition; 51,000 ohms ±5%; 2 w.
ARU	R-2149	3ZK6651-10	RESISTOR, fixed: metallized; 51,000 ohms ± 10%; 2 w; IRC #BT-2; (insulated; non-inductive; 1-3/4" lg x 5/16" diam; axial leads).

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
ACR	R-1467	3Z6655-3	RESISTOR, fixed: WW; 55,000 ohms ±1%; 1/2 w; WECo #107A.
SD	R-942	3RC21BE563K	RESISTOR, fixed: composition; 56,000 ohms ±10%; 1/2 w; IRC #BT-1/2.
RaR SD ARU	R-805 R-933 R-934 R-2178	3RC31BE563K	RESISTOR, fixed: composition; 56,000 ohms ±10%; 1 w; IRC #BT-1.
ARU	R-2175	3RC21BE623J	RESISTOR, fixed: composition; 62,000 ohms ±5%; 1/2 w; IRC #BT-1/2.
DUA	R-1498	3Z5907A-5	RESISTOR, fixed: WW; 65,000 ohms ±1%; 1/4 w; WECo #107-A.
RVA PPR	R-1123 R-1507	3RC21BE683J	RESISTOR, fixed: composition; 68,000 ohms ±5%; 1/2 w; IRC #BT-1/2.
RaR	R-813	3RC30BE683J	RESISTOR, fixed: composition; 68,000 ohms ±5%; 1 w; IRC #BT-1.
ACR	R-1469	3RC31BF683K	RESISTOR, fixed: composition; 68,000 ohms ±10%; 1 w.
ARR	R-2214	3RC41BE683K	RESISTOR, fixed: composition; 68,000 ohms ±10%; 2 w; IRC #BT-2.
ACCU	R-1401 R-1425	3Z5907A-2	RESISTOR, fixed: WW; 75,000 ohms ±1%; 1/4 w.
ARU	R-2166	3RC21BE753J	RESISTOR, fixed: composition; 75,000 ohms ±5%; 1/2 w; IRC #BT-1/2.
AETU ATU	R-423 R-473 R-522	3RC31BE753J	RESISTOR, fixed: composition; 75,000 ohms ±5%; 1 w; IRC #BT-1.
PPU	R-1652	3RC31BE753J	RESISTOR, fixed: carbon; 75,000 ohms ±5%; 1 w; 1-1/4″ lg x 1/4″ diam; IRC type #BT-1; Wemco dwg #T-7614143-495.
ACCU	R-1402 R-1426 R-1427 R-1430 thru R-1434 R-1439 R-1440 thru R-1444	3Z6680-16	RESISTOR, fixed: WW; 80,000 ohms ±1%; 3/4 w.
R	R-726 R-736	3RC21BE823K	RESISTOR, fixed: composition; 82,000 ohms ±10%; IRC #BT-1/2.
ACR	R-1468	3Z6700-76	RESISTOR, fixed: WW; 100,000 ohms ±1%; 1 w; WECo #107-A.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
AETU	R-420	3RC21BE104J	RESISTOR, fixed: composition; 100,000 ohms ±5%; 1/2 w; IRC # BT-1/2.
	R-421		
	R-470		
	R-471		
RU	R-603		
	R-630		
	R-684		
R	R-717		
	R-728		
	R-734		
R	R-741		
	R-742		
	R-757		
PPU	R-1630		
ARU	R-2122	3RC21BE104K	RESISTOR, fixed: composition; 100,000 ohms ±10%; 1/2 w; IRC # BT-1/2.
	R-2165		
ACCU	R-1412	3RC21BF104K	RESISTOR, fixed: composition; 100,000 ohms ±10%; 1/2 w.
	R-1435		
DU	R-129	3RC31BE104J	RESISTOR, fixed: composition; 100,000 ohms ±5%; 1 w; IRC # BT-1.
AETU	R-407		
	R-409		
	R-457		
	R-459		
	R-485		
RU	R-619		
	R-638		
RI	R-916		
PPU	R-1608		
	R-1648		
ACR	R-1470	3RC31BF104K	RESISTOR, fixed: composition; 100,000 ohms ±10%; 1 w.
	R-1471		
DU	R-133	3RC41BE104J	RESISTOR, fixed: composition; 100,000 ohms ±5%; 2 w; 5/16″ diam x 1-3/4″ lg; IRC # BT-2.
RU	R-645		
	R-662		
RI	R-909		
ReR	R-1001		
PPR	R-1501		
	R-1502		
PPU	R-1672		
ARR	R-2221		
RU	R-607	3RC21BE124K	RESISTOR, fixed: composition; 120,000 ohms ±10%; 1/2 w; IRC # BT-1/2.
	R-626		
RVA	R-1110	3RC31BE124K	RESISTOR, fixed: composition; 120,000 ohms ±10%; 1 w; IRC # BT-1.
PPR	R-1512 thru R-1517		
ACCU	R-1415	3RC21BF134J	RESISTOR, fixed: composition, 130,000 ohms ±5%; 1/2 w.
M	R-203	3Z6714-1	RESISTOR, fixed: carbon; 140,000 ohms ±10% 1 w; IRC # BT-1.
	R-204		
	R-205		
	R-206		

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
PPR	R-1505	3RC21BE154K	RESISTOR, fixed: composition; 150,000 ohms ±10%; 1/2 w; IRC # BT-1/2.
DU	R-104	3RC31BF154K	RESISTOR, fixed; metallized, fil ins; 150,000 ohms ±10%; 1 w; 1/4″ diam x 1-1/4″ lg; IRC # BT-1; Wemco dwg # T-7614142, part 420.
RI	R-904 R-905 R-906	3RC41BE154J	RESISTOR, fixed; composition; 150,000 ohms ±5%; 2 w; IRC # BT-2.
RU PPU	R-690 R-1653	3RC21BE164K	RESISTOR, fixed: composition; 180,000 ohms ±10%; 1/2 w; IRC # BT-1/2.
PPU	R-1603	3RC21BE184K	RESISTOR, fixed: composition; 180,000 ohms ±10%; 1 w.
DU	R-102	3RC41BE186K	RESISTOR, fixed: composition; 180,000 ohms ±10%; 2 w; IRC # BT-2.
ACCU	R-1417 R-1423	3RC21BF804J	RESISTOR, fixed: composition; 200,000 ohms ±5%; 1/2 w.
RI ARU	R-936 R-937 R-2123 R-2124 R-2125 R-2126 R-2179	3RC21BE224J	RESISTOR, fixed: composition; 220,000 ohms ±5%; 1/2 w; IRC # BT-1/2.
PPU	R-1669 R-1670	3RC21BE224K	RESISTOR, fixed: composition; 220,000 ohms ±10%; 1/2 w; IRC # BT-1/2.
M	R-225 R-226 R-227 R-228 R-229 R-230 R-231 R-232 R-233 R-234	3RC31BE224J	RESISTOR, fixed: composition; 220,000 ohms ±5%; 1 w; 1/4″ diam x 1-1/4″ lg; IRC # BT-1; Wemco dwg # T-7614143-462.
RU PPU OP	R-687 R-1671 R-1758 R-1759	3RC31BE224K	RESISTOR, fixed: composition; 220,000 ohms ±10%; 1 w; IRC # BT-1.
ACCU ACR	R-1428 R-1449 R-1454 R-1465 R-1476	3RC21BF244J	RESISTOR, fixed: composition; 240,000 ohms ±5%; 1/2 w.
ACR	R-1464 R-1472	3RC31BF244J	RESISTOR, fixed: composition; 240,000 ohms ±5%; 1 w.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
OPS	R-951 R-953 R-958 R-961 R-970	3RC20BE274K	RESISTOR, fixed: composition; 270,000 ohms ±10%; 1/2 w; AB #EB #2741; (3/8″ wd x 9/64″ diam; bakelite; no terms but 1-1/2″ lg #20 gauge wire leads; point to point mtg).
ARU	R-2177	3RC31BE274K	RESISTOR, fixed: composition; 270,000 ohms ±10%; 1 w; IRC #BT-1.
PPU	R-1623	3RC21BE304J	RESISTOR, fixed: composition; 300,000 ohms ±5%; 1/2 w; IRC #BT-1/2.
ACCU	R-1409 R-1410 R-1411	3RC31BF304J	RESISTOR, fixed: composition; 300,000 ohms ±5%; 1 w.
ARU ARR	R-2127 R-2205	3RC21BE634K	RESISTOR, fixed: composition; 330,000 ohms ±10%; 1/2 w; IRC #BT-1/2.
RU	R-627	3RC31BE554K	RESISTOR, fixed: composition; 330,000 ohms ±10%; 1 w; IRC #BT-1.
DU	R-134	3RC31BE394K	RESISTOR, fixed: composition; 390,000 ohms ±10%; 1 w; IRC #BT-1.
RaR	R-809 R-810 R-811 R-812	3RC41BE394J	RESISTOR, fixed: composition; 390,000 ohms ±5%; 2 w; IRC #BT-2.
RU R RaR RI RVA PPR PPU	R-617 R-724 R-733 R-808 R-914 R-915 R-1107 R-1604 R-1663 R-1664 R-1665 R-1666	3RC21AE474K	RESISTOR, fixed: composition; 470,000 ohms ±10%; 1/2 w; IRC #BT- 1/2.
ACR	*R-1478	3RC21BF474K	RESISTOR, fixed: composition; 470,000 ohms ±10%; 1/2 w.
PPR	R-1518 R-1519 R-1520 R-1521 R-1522 R-1523 R-1524 R-1525 R-1526 R-1527 R-1528	3RC41BE474K	RESISTOR, fixed: composition; 470,000 ohms ±10%; 2 w; IRC #BT-2.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
AETU RU ARU	R-418 R-468 R-657 R-2104 R-2128 R-2129 R-2130 R-2131 R-2132 R-2133 R-2134 R-2135 R-2173	3RC21BE514J	RESISTOR, fixed: composition; 510,000 ohms ±5%; 1/2 w; IRC # BT-1/2.
SD	R-926 R-927 R-929 R-930 R-931 R-932 R-938 R-939	3RC21BE564K	RESISTOR, fixed: composition; 560,000 ohms ±10%; 1/2 w; IRC # BT-1/2.
ACCU	R-1413 R-1458	3RC21BF564K	RESISTOR, fixed: composition; 560,000 ohms ±10%; 1/2 w.
SD	R-935	3RC31BF334K	RESISTOR, fixed: metallized, fil ins; 0.33 meg ±10%; 1 w; 1-1/4" lg x 1/4" diam; IRC type BT-1; Wemco dwg 7614145, part 585.
ACCU	R-1448 R-1453	3RC21BF105J	RESISTOR, fixed: composition; 1 meg ±5%; 1/2 w.
ACCU ACR	R-1436 R-1450 R-1480 R-1488	3RC21BF105K	RESISTOR, fixed: composition; 1 meg ±10%; 1/2 w.
AETU RU PPU LO	R-401 R-402 R-403 R-404 R-451 R-452 R-453 R-454 R-674 R-688 R-694 R-695 R-696 R-1631 R-1659 R-1684 R-1823 R-1824 R-1825	3RC21BE105K	RESISTOR, fixed: composition; 1 meg ±10%; 1/2 w; IRC # BT-1/2.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
AETU	R-431 R-432 R-481 R-482	3RC31BE105K	RESISTOR, fixed: composition; 1 meg ±10%; 1 w; IRC #BT-1.
ACR	R-1475	3RC31BF105K	RESISTOR, fixed: composition; 1 meg ±10%; 1 w.
R	R-740	3RC21BE155K	RESISTOR, fixed: composition; 1.5 meg ±10%; 1/2 w; IRC #BT-1/2.
PPR ARU	R-1503 R-2136	3RC21BE185K	RESISTOR, fixed: composition; 1.8 meg ±10%; 1/2 w; IRC #BT-1/2.
ACR	R-1463	3RC21BF205J	RESISTOR, fixed: composition; 2 meg ±5%; 1/2 w.
PU PI	R-601 R-1239	3RC21BE225K	RESISTOR, fixed: composition; 2.2 meg ±10%; 1/2 w; IRC #BT-1/2.
ACCU	R-1445	3RC21BF225K	RESISTOR, fixed: composition; 2.2 meg ±10%; 1/2 w.
AETU	R-437 R-488	3RC21BF275K	RESISTOR, fixed: metallized fil ins; 2.7 meg ±10%; 1/2 w; 5/8″ lg x 3/16″ diam; IRC type BR-1/2; Wemco dwg #T-7614146, part 614.
RU	R-643 R-660 R-678 R-683	3RC21BE335J	RESISTOR, fixed: composition; 3.3 meg ±5%; 1/2 w; IRC #BT-1/2.
AETU	R-436 R-487	3RC21BF335K	RESISTOR, fixed: composition; 3.3 meg ±10%; 1/2 w; 3/16″ diam x 5/8″ lg; IRC type BT-1/2; Wemco; part 613; dwg #T-7614146.
M ARU ARR	R-218 R-219 R-220 R-221 R-2142 R-2204	3RC31BE335K	RESISTOR, fixed: composition; 3.3 meg ±10%; 1 w; IRC #BT-1.
ARU	R-2137 R-2138 R-2140 R-2141	3RC31BE395J	RESISTOR, fixed: composition; 3.9 meg ±5%; 1 w; IRC #BT-1.
RU R PPU	R-653 R-670 R-739 R-1609 R-1612 R-1622 R-1625	3RC21BE475K	RESISTOR, fixed: composition; 4.7 meg ±10%; 1/2 w; IRC #BT-1/2.
CP TrL	R-1760 R-1761 R-1982 R-1983	3RC21BE106K	RESISTOR, fixed: composition; 10 meg ±10%; 1/2 w; IRC #BT-1/2.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
SD	R-928	3RC21BE186K	RESISTOR, fixed: composition; 18 meg ±10%; 1/2 w; IRC # BT-1/2.
PPU	R-1679 R-1682	2Z7278-34	RESISTOR, variable: WW; 200 ohms ±10%; 3 w; single; linear taper; enclosed case; 1-3/8″ diam x 9/16″ diam behind panel; 3/8″ lg shaft; GE dwg # P7764626, part 3; (potentiometer).
RI	R-902	3Z7225-3	RESISTOR, variable: WW; 250 ohms ±10%; 25 w; linear taper; 1-21/32″ diam x 31/32″ d, behind panel; shaft 1/4″ diam x 1/2″ lg; IRC PR-25; (rheostat).
DU	R-101	2Z7278-36	RESISTOR, variable: WW; 300 ohms ±10%; 3 w; linear taper; 1-3/8″ diam x 9/16″ d, shaft 1/4″ diam x 7/16″ lg; Centralab type V; Wemco pt/dwg # T-7614142, part 418.
PPU	R-1674	3Z7235-2.1	RESISTOR, variable: WW; 350 ohms ±10%; 25 w; single type; linear taper; 1-21/32″ diam x 31/32″ d, behind panel; shaft 1/4″ diam x 7/16″ lg; GE dwg # P7764636, part 2; (rheostat).
PCU	R-1302	2Z7278-67	RESISTOR, variable: WW; all metal power rheostat; low temp rise 350 ohms ±10%; 75 w; 3 term; 2-3/8″ diam a 1-3/8″ x 1/2″ diam shaft; IRC type PR-75; Wemco dwg # 7614144, part 509.
ATU	R-514	3Z7250-16	RESISTOR, variable: WW; 500 ohms ±10%; 2 w; 1/2″ x 1-3/64″ OD; diam of shaft 1/4″; lg of bushing and shaft 13/16″; bushing 3/8″ lg; Centralab; Wemco dwg # T-7614141, part 379.
AETU	R-408 R-458	3Z7250-2	RESISTOR, variable: WW; 500 ohms ±10%; 25 w; 222 ma max; over-all 1-21/32″ diam x 1-31/32″ lg; 1/4″ diam steel shaft w/1/2″ extension beyond bushing; 3/8″-32; bushing 1/2″ lg; IRC type PR-25; (rheostat).
M	R-223	3Z7250-18	RESISTOR, variable: WW; 500 ohms ±10%; 75 w; three term; body 2-3/8″ diam x 1-3/8″ d, shaft 1/4″ diam 7/8″ lg; IRC type PR-75; (potentiometer); Wemco dwg # T-7614143-461.
M	R-222	3Z7275-4	RESISTOR, variable: WW; 750 ohms ±10%; 25 w; three term; 1-21/32″ diam x 21/32″ d; shaft 0.218″ diam x 15/16″ lg; IRC type PR-25; (rheostat) w/screwdriver slot.
R	R-749	2Z7279-48	RESISTOR, variable: WW; 1,000 ohms ±10%; 3 w; linear taper; screwdriver slot; molded bakelite base; 1-3/8″ diam x 9/16″ d, shaft 1/4″ diam x 9/16″ lg; GE dwg # P7764626, part 5; (potentiometer).

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
OPS	R-964 R-967 R-968	2ZK7296-1M.4	RESISTOR, variable: WW; 1,000 ohms ±10%; 2 w; linear taper; 1-1/4″ diam x 9/16″ d; shaft 1/4″ diam x 3/4″ lg; (potentiometer).
ARU	R-2183 R-2184	2Z7269.146	RESISTOR, variable: carbon; 2,000 ohms; 2 w; 3 term; body 1-1/16″ diam x 3/4″ d; shaft 1/4″ diam x 1-5/8″ lg; AB type # J; Bradley Ometer w/shaft locking per AB dwg # Y-5488-D; (potentiometer).
AETU	R-414 R-415	3Z7320-5	RESISTOR, variable: carbon dual; ea sect 2,000 ohms ±10%; 2 w; 3 term ea sect; 1-1/4″ d x 1-1/4″ diam; IRC; type # W (dual); Wemco dwg # T-7614141PT399.
RU PPU	R-634 R-1638 R-1644	2Z7269.30	RESISTOR, variable: carbon; 2,500 ohms ± 10%; 2 w; linear taper; 1-1/16″ diam; shaft 1/4″ diam x 2″ lg; GE dwg # P7764622, part 12; (potentiometer) 13/16″ shaft.
ACCU	R-1404 R-1405	2Z7280-76	RESISTOR, variable: WW; 2,500 ohms ±10%; 4 w; 1-17/32″ diam w/1220 Shakeproof lock-washer; (potentiometer).
AETU ATU R	R-412 R-462 R-516 R-743	2Z7269.31	RESISTOR, variable: carbon; 3,000 ohms ± 10%; 2 w; linear taper; 1-1/8″ diam x 9/16″ d behind panel; shaft 1/4″ diam x 7/16″ lg; GE dwg # P7764622, part 13; (potentiometer).
OPS	R-957	2Z7269.145	RESISTOR, variable: carbon; 3,000 ohms ± 10%; 2 w; 3 term; body 1-1/16″ diam x 9/16 d; shaft 1/4″ diam x 1-5/8″ lg; AB type # J; (potentiometer).
CP	R-1752	2Z7280-124	RESISTOR, variable: WW; 3,000 ohms ±10%; 4 w; 3 term; body 1-5/8″ diam x 9/16″ d; shaft 1/4″ diam x 13/16″ lg from mtg surface; Mallory # A3MP; Wemco dwg # T-7614141-387; (potentiometer).
DUA	R-1490	3Z7330	RESISTOR, variable: WW; 3,000 ohms; 25 w; w/screwdriver slot and locking device shaft lg 1/8″ beyond retaining ring; lg of bushing for 1/16″ panel and shaft; Ohmite model H (rheostat).
ARU	R-2181	2Z7269.147	RESISTOR, variable: carbon; 5,000 ohms; 2 w; 3 term; body 1-1/16″ diam x 3/4″ d; shaft 1/4″ diam x 1-3/8″ lg beyond bushing; AB type # JS (potentiometer).
RU	R-636	2Z7280-64	RESISTOR, variable: WW; 5,000 ohms ±10%; 3 w; single; linear taper w/screwdriver slot; 1-3/8″ diam x 9/16″ d behind panel; shaft 1/4″ diam x 7/16″ lg; Centralab type # VF-135; (potentiometer).
PPU	R-1614	3Z7350-17	RESISTOR, variable: (potentiometer) WW; 5,000 ohms ±10%; 3 w; 3 term; 1-3/8″ diam x 9/16″ d; 2-1/2″ shaft Centralab; similar to type VF; Wemco dwg # T-7614144, part 507.

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Major component	Reference symbol	Signal Corps stock No.	Name of part and description
ACCU	R-1403 R-1420	2Z7280-78	RESISTOR, variable: WW; 7,500 ohms ±10%; 3 w; 1-17/32″ diam; w/1220 shakeproof lockwasher (potentiometer).
M	R-237	3Z7550-10	RESISTOR, variable: WW; 5,000 ohms; 25 w; linear taper; IRC type PR-25 (rheostat).
RaR	R-807	2Z7269.74	RESISTOR, variable: (potentiometer) metallized res coated bakelite; 10,000 ohms ±10%; 1/2 w; 3 term; 1-1/4″ diam x 9/16″ d; IRC 0.2; Wemco dwg #T-7614144, part 549.
R	R-738	2Z7269.29	RESISTOR, variable: carbon; 10,000 ohms ± 10%; 2 w; linear taper; 1-1/16″ diam x 3/8″; shaft 1/4″ diam x 2″ lg; GE dwg #P7764622, part 18; (potentiometer).
ACR	R-1462	2Z7280-77	RESISTOR, variable: WW; 10,000 ohms ±10%; 3 w; 1-17/32″ diam; w/1220 shakeproof lockwasher (potentiometer).
CP	R-1753	2Z7280-123	RESISTOR, variable: WW; 10,000 ohms ±10%; 4 w; three term; body 1-5/8″ diam x 9/16″ d; shaft 1/4″ diam x 13/16″ lg from mtg surface; Mallory #A10MP; Wemco #T-7614141-408 (potentiometer).
ARR	R-2215	2Z7281.101	RESISTOR, variable: (potentiometer); 15,000 ohms ±10%; 1 w; straight taper; 1-5/8″ diam; 13/16″ d; shaft 1/4″ diam; bushing and shaft 13/16″ lg from mtg surface; Clarostat, part 58; Wemco dwg #T-7614141, part 360.
LO	R-1817	2Z7281.31	RESISTOR, variable: WW; 15,000 ohms ±10%; 4 w; single sect; linear taper; 1-5/8″ diam x 1-1/8″ d; shaft 1/4″ diam x 7/16″ lg; GE dwg #P7764637, part 2; (potentiometer).
RI	R-903	2Z7281.32	RESISTOR, variable: (potentiometer) range; special; WW; one winding 20,000 ohms; 1 slider cont and resistor 10,000 ohms; 14-7/16″ lg; 13-3/4″, 5-21/32″ h; WECo #7709390, part 1.
RI	R-901	3Z7420-4	RESISTOR, variable: WW; 20,000 ohms ±10%; 12 w; single sect; linear, no taps; 3″ diam x 2-5/8″ d, behind panel; shaft 3/8″ diam x 3/4″ lg; GE dwg #K-8276467; p/o Indicator BC-1088-B; (rheostat).
ATU	R-505 R-506	2Z7284-40	RESISTOR, variable: WW; dual; 250,000 ohms ±10%; (ea sect) 2 w; 3 term ea sect; 1-1/16″ diam x 9/16″ d; 3/16″ lg of shaft x 1/4″ diam; Allen-Bradley type #J; Wemco dwg #T-7614141, part 386.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
RU PPR PPU	R-616 R-1506 R-1632	2Z7270.76	RESISTOR, variable: carbon; 25,000 ohms ± 10%; 2 w; single type; linear taper; 1-1/8″ diam x 9/16″ d, behind panel; shaft 1/4″ diam x 7/16″ lg; GE dwg # P7764622, part 2; (potentiometer).
LO	R-1806	2Z7281.27	RESISTOR, variable: WW; 25,000 ohms ± 10%; 4 w; linear taper w/screwdriver slot; 1-5/8″ diam x 1-1/16″ d, behind panel; Clarostat type # P10-W; (potentiometer).
AETU R	R-433 R-727	2Z7270.108	RESISTOR, variable: carbon; 50,000 ohms ± 10%; 2 w; linear taper; 1-1/16″ diam x 9/16″ d; shaft 1/4″ diam x 2″ lg; GE dwg # 7764622, part 14; (potentiometer).
RU	R-656 R-673	2Z7271-68	RESISTOR, variable: carbon; 75,000 ohms ± 10%; 2 w; single type; linear taper; 1-1/8″ diam x 9/16″ d, behind panel; shaft 1/4″ diam 3 8″ lg; GE dwg # 7764622, part 3; (potentiometer).
RU RI	R-624 R-910 R-911	2Z7271-65	RESISTOR, variable: carbon; 100,000 ohms ± 10%; 2 w; linear taper; 1-1/8″ diam x 9/16″ d; shaft 1/4″ x 13/16″ lg; GE dwg # P7764622, part 11, (potentiometer).
PPU	R-1604 R-1605 R-1658		
RI	R-907 R-908	2Z7272-32	RESISTOR, variable: carbon; 300,000 ohms ± 10%; 2 w; IRC type CP; (potentiometer).
AETU RU PPU	R-424 R-474 R-621 R-625 R-646 R-663 R-698 R-699 R-1624	2Z7272-31	RESISTOR, variable: carbon; 500,000 ohms ± 10%; 2 w; linear taper; 1-1/16″ diam x 1-3/8″; shaft 1/4″ diam x 2″ lg; GE dwg # P7764622, part 6; (potentiometer).
ATU RU CP	R-504 R-622 R-623 R-628 R-629 R-1751	2Z7273-2	RESISTOR, variable: (potentiometer) metallized resistance coated bakelite; 1 meg ± 10%; 2 w; 3 term; 1-1/4″ diam x 9/16″ dp; IRC CP; Wemco dwg # T-7614144, part 529.
ARU	R-2185	2Z7273-82	RESISTOR, variable: carbon; 1 meg; 2 w; 3 term; body 1-1/16″ diam x 3/4″ d; shaft 1/4″ diam x 1-3/8″ lg beyond bushing; AB type # JS; (potentiometer).
ARU	R-2182	2Z7274-47	RESISTOR, variable: carbon; 2 meg; 2 w; 3 term; body 1-1/16″ diam x 3/4″ d; shaft 1/2″ diam x 1-5/8″ beyond bushing; AB type # JS (potentiometer).

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
M	R-206 R-207	2Z9402.204	RESISTOR BOARD ASSEMBLY: 26 brass pin inserts 13/16″ diam x 1″ lg on 1/2″ mtg/c w/14 resistors, R-206, of 140,000 ohms ±10%; 1 w; IRC type #BT-1 and 1 resistor, R-207, of 40,000 ohms ±10%; 1 w; IRC type BT-1; on bakelite board, 7-13/16″ lg x 2-3/8″ wd x 1/2″ thk over-all; Wemco part/dwg #7416087-G1; Wemco dwg #T-7614143-455.
M	R-203 R-204 R-205	2Z9402.205	RESISTOR BOARD ASSEMBLY: 26 brass pin inserts 13/16″ diam x 1″ lg on 1/2″ mtg/c w/25 resistors of 140,000 ohms ±10%; 1 w; IRC type #BT-1; on bakelite board; 7-13/16″ lg x 2-3/8″ wd x 1/2″ thk over-all; Wemco part/dwg #7408543-G1; Wemco part/dwg #T-7614143-454.
		6L4970-8	SCREW, cap: "Unbrako" steel; socket head; 10-32 x 1/2″ lg.
		6L17503-19.49S	SCREW, thumb: knurled cylindrical head; steel; 3/16″–32 thds per inch; 1-7/32″ lg over-all; 7/16″ lg thd; 9/16″ diam of head; Palmer-Bee Co PI 307-495; Wemco dwg #M-7417540, part 47.
		2Z3295-34	SHAFT, coupling: flexible; brass hub; outside hub surfaces painted black; 2-1/2″ lg x 1-1/4″ wd; Lord cat. #J-1211-3; Wemco dwg #T-7614150-846.
		2Z8320-7	SHIM: spacer; 3/8″ diam x 0.002″ thk; hole through middle 7/32″ diam; Palmer-Bee Co PI 307-496; Wemco dwg #M-7417540, part 46.
TrL		2Z8502-P45	SHOCK MOUNT: antivibration; Lord #153-p-45; (over-all 1-1/2″ lg x 1-3/4″ wd x 1.125″ d; capacity 45 lb load; four mtg holes; 0.196″ diam; 1-1/7″ apart; center sleeve 0.257″ diam x 1-1/2″ lg; Pioneer 9522).
M		2Z8403-4	SHOCK MOUNT: 10-lb load limit; US rubber #A-301 mod; WECo #ESP-716609 (over-all dimen 1-1/4″ lg x 9/16″ diam, or 3/8″ lg x #8 (0.164″)-32 AN thd from ea end).
TrL		2Z8404-6	SHOCK MOUNT: Lord #153 PH-15; GE #K7888733 P1 (w/cadmium-plated holder; dimen 2-3/8″ x 2-3/8″ x 1-1/16″ h; center hole 0.257″ diam; four mtg holes 0.196″ diam; mtg/c 1-15/16″ on sq).
TrL		2Z8407-1	SHOCK MOUNT: load rating 280 lbs; Lord type 281-P-280 GE dwg ML7765115-G1; (plate dimen 3-1/4″ x 3-1/4″ x 1/8″ thk; four mtg holes 0.328″ diam centered on sq 2-9/16″ apart; center holes 0.516″ diam; rubber sect 2-1/4″ h, top diam 2-7/8″, bottom diam 2-3/4″).

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
		3G1971-18	SLEEVING, black braided cotton: varnish saturated and coated; 0.42″ ID x 0.072″ OD; Wemco PD spec No. #4038-E size #18; Wemco dwg #7614152, part 940.
		3G1971-14	SLEEVING, black braided cotton: varnish saturated and coated; 0.066″ ID x 0.096″ OD; Wemco PD spec No. #4038-E size #14; Wemco dwg #7614152, part 941.
		3G1971-10	SLEEVING, black braided cotton: varnish saturated and coated; 0.106″ ID x 0.136″ OD; Wemco PD spec No. #4038-E size #10; Wemco dwg #7614152, part 942.
		3G1971-8	SLEEVING, black braided cotton: varnish saturated and coated; 0.133″ ID x 0.169″ OD; Wemco PD spec No. #4038-E size #8; Wemco dwg #7614152, part 943.
		3G1971-7	SLEEVING, black braided cotton: varnish saturated and coated; 0.148″ ID x 0.184″ OD; Wemco PD spec No. #4038-E size #7; Wemco dwg #7614152, part 944.
		3G1971-6	SLEEVING, black braided cotton: varnish saturated and coated; 0.166″ ID x 0.202″ OD; Wemco PD spec No. #4038-E size #6; Wemco dwg #7614152, part 945.
		3G1971-5	SLEEVING, black braided cotton: varnish saturated and coated; 0.186″ ID x 0.222″ OD; Wemco PD spec No. #4038-E size #5; Wemco dwg #7614152, part 946.
RaR	X-801 X-802 X-803	2Z8674.8	SOCKET: tube; 4 prong; Amphenol #S4; (bakelite; female; mtg 1-1/8″ diam hole; w/#4 retainer ring; fits steel chassis 16 to 19 ga).
RaR PPR	X-810 X-1503	2Z8674.15	SOCKET: tube; 4 cont; Amphenol #77A-4T; safety socket 1-7/16″ OD; 1-5/8″ lg recess for tube base 7/8″ d; metal mtg, ring 2 hole 9.136″; 1-13/16″ centers; mica filled bakelite insulation.
DU	X-109	2Z8687	SOCKET, 5 pin: S5# 4 Ring.
DU	X-103 X-104 X-105	2Z8663-1	SOCKET, tube: 7 cont; steatite; Johnson type #247.

358. MAINTENANCE PARTS LIST FOR RÀDIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
DU	X-101 X-102 X-106 X-107 X-108	2Z8795.11	SOCKET: vacuum tube; octal; Amphenol #RS-8; 6X5GT; black.
AETU	X-401 thru X-408 X-451 thru X-458		
ATU	X-501 thru X-505		
RU	X-601 thru X-616		
R	X-701 thru X-714		
RaR	X-804 thru X-809		
SU	X-926 thru X-930		
OPS	X-951 X-952 X-953		
ReR	X-1001 thru X-1004		
RVA	X-1101 thru X-1104		
FS	X-1152		
PPR	X-1501 thru X-1507		
PPU	X-1601 thru X-1618		
CP	X-1751 X-1752		
LO	X-1801 X-1802 X-1804 thru X-1807		
TrL	X-1976		
ARU	X-2101 thru X-2117		
ARR	X-2201 thru X-2210		

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
LO	X-1803	2Z8678.5	SOCKET: tube; 8 prong; female; Amphenol #PF-8-7T (low loss, mica filled, bakelite; 1-3/16″ diam x 1-3/32″ lg; connection on side; black steel cap fiber-lined).
ACCU ACR	X-1401 thru X-1406 X-1451 thru X-1458	2Z8678.16	SOCKET, tube: 8 prong; oval 1-1/4″ x 1-25/32″ x 11/16″ thk; Cinch type 9881.
PPI	X-1701	2Z8678.10	SOCKET, tube: 8 conts; Amphenol type PF8-7M; GE dwg #K7888183 (bakelite; 1-1/4″ diam x 1-5/32″ h; side outlet w/Grommet; takes up to 7/8″ diam cable).
PA	X-1851 X-1852	2Z8654.7	SOCKET, tube: Amphenol type S-8TM w/#4 retainer ring; (mica filled bakelite 1/2″ thk; 1-1/4″ flange; 1.158 chassis hole; phosphor bronze tinned term).
RI	X-901 X-902	2Z8682.14	SOCKET, tube: 12 cont; RCA 9952; (shell type 1.1″ h x 2.219″ diam bakelite shell 1/16″ thk at upper rim; approx x 2″ OD; 9/16″ x 2.219″ collar at base, grooved w/4 kegways for K870,390-1 (9943) RCA socket base clamp; per RCA dwg M426865-501).
PPI	I-1701 I-1702 I-1703	2Z5883-185	SOCKET, dial light: steel; cadmium pl; 1/2″ lg x 3/8″ diam; Cinch; #7597; 6-8v, 2.5 amps; flange mtg; 1/4″ diam mtg hole.
M	X-205 thru X-211	2Z8759.4	SOCKET, tube: ux bayonet 4 cont; steatite ceramic; glazed base w/brass nickel pl shell; 2-13/16″ diam x 2″ h over-all; Wemco #7706097-G1.
M	X-203 X-204	2Z8759.3-1	SOCKET, tube: 4 term; screw in socket; metal shell; ceramic mtg base; 3-1/2″ diam x 2-1/4″ h; EF Johnson cat. #211; Wemco dwg #7710202-G1.
M	SG-201 SG-202	2Z8808-13	SPARK GAP: base micarta, phosphor bronze; meter protection; 4-5/8″ lg x 2-1/2″ wd x 1-9/16″ thk; Wemco dwg #7713711-G1.
TrL	K-1977	3H5310-8	STARTER, motor; magnetic; metal cabinet; black E; line starter; 15v AC; 60 cyc; 1 amp; 6-1/4″ lg x 4-5/8″ wd x 4-3/64″ d over-all dimen; Wemco Deion type; class #11-200.0; Wemco pt/dwg #T-7614138-235.
ACCU		2Z9406.120	STRIP, terminal: 6 Cinch #1464 solder lugs; black phenol fibre; 3-1/8″ lg x 3/8″ wd x 1/16″ thk; WECo #ES-696537-2, Wemco dwg #M-7417480-94.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
RI	S-902	3Z9844	SWITCH, screw term type: SP bakelite; 3 amp; 250v; 6 amp; 126v; 1-3/32″ lg x 43/64″ wd x 5/8″ thk; C-H, part 8396; Wemco, part 620; dwg # T-7614146.
AD		3Z9823.11	SWITCH, sensitive: plunger type; bakelite; approx 2″ x 1-1/8″ x 11/16″; Micro Sw; per Dielectric Prod Co pt/dwg # AD-18-14; Wemco dwg # 7416899P8; 10A 125v, 5A 250v, 3A 460v, 2A 600v AC; plunger type, normally closed.
DUA	S-1492	3Z9580-15.1	SWITCH, SPST: single sect; 2 nuts; 3 amp at 250v; 6 amp at 125v; shorting type; cont lever; ball type; AH&H # 86993-GA; WECo dwg # ESO-676800-31.
AD		3Z9838	SWITCH, thermo: brass; approx 5-1/16″ lg x 1-5/32″ diam; Fenwall Inc; per Dielectric Prod Co pt/dwg # AD-18-3; Wemco dwg # 7416899, part 17.
DP	S-1909	3Z9849.173	SWITCH, toggle: SPDT; 2 position; bakelite case; 21/32″ d x 5/8″ wd x 1-1/8″ lg over-all; C-H # 8810K4; Wemco dwg # 7614146, part 618.
RU	S-602	3Z8142	SWITCH, SW-142 (dwg SC-D-4187, toggle; DPDT; 3 amp; 250v; C-H # 8363 or equal).
RI	S-903	3Z9825-74.15	SWITCH, rotary: Mallory type RL; GE dwg # K8276504 (2 circuit, 3 position; nonshorting cont; bakelite insulation; round, 1-5/8″ 2-1/2″ diam; bushing 3/8″ x 3/8″-32).
CP	S-1755	3Z9825-74.16	SWITCH, rotary: Centralab # 2505 modified; GE dwg # M-7467779, part 1; (2 pole; 2 position; shorting teeth; ceramic wafer type; stainless steel; 3/8″-32 x 3/8″ mtg bushing; 0.240″ diam shaft 7/8″ lg; Isolantite; over-all 2″ lg x 1-5/8″ diam).
CP	S-1751	3Z9825-74.17	SWITCH, rotary: Centralab # 2505 modified; GE dwg # M-7467779, part 1; (2 pole, 4 position; shorting teeth; ceramic wafer type; stainless steel; 3/8″-32 x 3/8″ bushing; shaft 0.240″ diam x 7/8″ lg; Isolantite insulation; over-all 2″ lg x 1-5/8″ diam).
DP	S-1907	3Z9825-74.20	SWITCH, rotary: Centralab type # 2515 modified per GE dwg # M-7467761, part 1; (8 pole, 2 position; silver pl conts special arranged; nonshorting type cont; ceramic body; 1-7/8″ lg x 1-5/8″ wd; brass bushing 3/8″ lg x 3/8″-32; shaft 7/8″ lg x 1/4″ diam).
RU	S-601	3Z9825-74.21	SWITCH, rotary: Centralab type # 2501 modified per GE dwg # M-7467761, part 2; (SP2 position; 1 sect; silver pl cont special arrangement; nonshorting; ceramic body).

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
CP	S-1760	3Z9849.34	SWITCH, toggle: SPST; C-H #8817-K2; (momentary nominal rating 20 amp, 24v; bushing 11/32"-32 thd; 2 solder lug term w/7/64" diam hole; over-all 1-1/2" lg, 5/8" wd, 21/32" d, toggle is 11/16" lg; bakelite insulation).
R RI	S-702 S-904	3Z9849.31	SWITCH, toggle: C-H #8282 SPDT; solder lug type; (1" x 17/32" wd x 1/2" lg; 1 amp; 250v; 3 amp, 125v).
CP	S-1761	3Z9849.60	SWITCH, toggle: C-H #8825K2 (DPDT; 20 amps at 24v; silver cont, bat type lever w/nonluminous end; solder lug term 9/16" lg; metal support plate on bakelite housing; locking ring to prevent rotation; over-all 1-5/16" lg x 3/4" wd x 25/32" d; bushing 15/32" diam 32 thd x 11/16" lg).
ACCU	S-1401	3ZK9858-14	SWITCH, toggle: DPDT; AH&H per WECo dwg #ES-676800-18; 3 amp at 250v; 6 amp at 125v; wiping cont; molded phenol plastic case.
ACCU	S-1402	3ZK9848.17	SWITCH, toggle: DPDT; AH&H #81027L; 3 amp at 250v; mtg sleeve 15/32"; 32 thd; 13/32" lg; ball type lever.
PPI	S-1701	3Z9824-31.41	SWITCH, interlock: normally open; 3 amp, 250v; AH&H type #3593-E; Wemco part/dwg #T-7614146, part 637.
TrL	K-1976	3H5310-9	STARTER, motor: magnetic; metal cabinet; black enameled; line starter; 115v AC; 60 cyc, lamp; 6-1/4" lg x 4-5/16" wd x 4-3/64" d over-all dimen; Wemco Deion pt/dwg #T-7614138-234.
ACR	S-1451	3Z9508	SWITCH, DIST: 6/12 amp; 250/125v; AH&H cat. #80600.
ATU R RaR ReR PPR CP LO DP ARR	S-501 S-701 S-801 S-1001 S-1501 S-1753 S-1754 S-1756 S-1759 S-1801 S-1802 S-1905 S-1906 S-1908 S-2201	3Z9849.106	SWITCH, DPST: bakelite; 10 amp, 250v; 3/4" wd x 1-11/32" lg x 21/32" thk; C-H part 7522; Wemco dwg #K7812053, part 1.
M	S-204 thru S-210	3Z9590-1	SWITCH, lock: SPST; molded phenolic; 2-7/8" lg x 9/16" wd x 11/16" h over-all; normally open; nonfuseable; solder lug terms; Wemco dwg #P-7713229-G2.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
M TrL	S-212 S-1926 S-1977	3Z9558-34.1	SWITCH, limit: transformer; SPST; single sect; 10 amp; 120v AC; momentary 2 cont; 1 normally open; 1 normally closed; non-shorting; roller leaf actuation; 5 oz pressure; micro switch type #WZ-R12.
AETU	S-401	3Z9818-9.1	SWITCH, lever type locking: Clare CP type G; #4-5v DC; 3 amp; 150 w; cont arrangement; 8 circuit; normally open.
RI	S-901	3Z9558-11.1	SWITCH, micro: spring plunger; micro switch #WZ-RS; type S; 10 amp at 125v; 5 amp at 250v AC; normally closed; bakelite case w/white top 1-15/16″ x 1″ x 53/64″ h x 11/16″ w; plunger post approx 1/2″ h; 2 mtg holes through switch body 1″ centers; 0.139″ diam; single circuit; quick break.
M	S-201 S-202 S-203	3Z9558.3	SWITCH, SPST normally open; bakelite body; 1-11/16″ diam x 2-7/16″ over-all; micro type #YZ-RL2.
CP	S-1752	3Z9710-7.1	SWITCH, SPST: normally open; bakelite case; 1-15/16″ diam x 11/16″ w x 27/32″ lg over-all; Acvo Elec Co type #RD7-1P; 12-16 oz operating pressure.
CP	S-1762 thru S-1767	3Z9824-271.3	SWITCH, push: SPST; 3 amp; 125v AC; 60 cyc; normally open; shorting type cont; Wemco dwg #6-B-2868; style #1246468.
DP	S-1910	3Z9849.128	SWITCH, SPST: 2 applicable cont; bakelite case with metal top; 21/32″ x 5/8″ x 1-1/8″ over-all dimen; C-H #8801K-5; 15/32″-32 thd single hole mtg; 2 #6-32 x 3/16″ lg screw terms.
CP	S-1757 S-1758	3Z9824-271.2	SWITCH, push button type SO-2: 2 buttons, 3 wire; single circuit; 1 normally open 1 normally closed; 1 sect; bakelite body; 2-1/8″ x 1-10/32″ x 1-14/16″ over-all; Wemco style #1246466; 110-125v AC; 3 amps; shorting cont; 1 mtg hole 0.190 diam screw terms.
AD		3Z9862-8	SWITCH, power: SPDT; bakelite; approx 1-3/4″ x 3/4″ x 1-5/8″ d; AH&H (per Dielectric Prod Co pt/dwg #AD-26-3) 6A 250v; 12A 125v; tumbler; Wemco dwg #7416899, part 11.
M	S-211	3Z9858-8.114	SWITCH, 2 pole; 2 position; AH&H #81057-BA.
PPU	S-1601	3Z9825-74.16	SWITCH, rotary: 1 sect; 2 pole; 2 position; shorting teeth; Centralab #2505 modified.
		2C7984-1086C	TRACKING UNIT BC-1086-C: (automatic); Wemco #DL-7502455-G2.
		2C7984-1090C	TRACKING UNIT BC-1090-C: (azimuth and elevation); Wemco #DL-7502454-G2.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
		2C6996-1372	TRACKING UNIT, range: BC-1372; (automatic range); Wemco # DL-7502885-G2.
ARU	T-2104	2Z9638-38	TRANSFORMER, AF: oscillator-blocking; enclosed metal case; 2-1/4″ h x 1-3/8″ wd x 2-5/32″ d; 3 windings ea 20 ohms impedance; Wemco type # 132 DWP; Wemco dwg # T-7614148-7B.
ARU	T-2101 T-2102 T-2103	2Z9641.151	TRANSFORMER, IF: interstage coupling; shielded 2-5/32″ diam x 2-1/4″ lg; Wemco type # 145EWP; hypersil core untuned; Wemco # L-420802.
PCU	T-1302 T-1352	2Z9614-21	TRANSFORMER, power: motor drive; metal case 2-1/2″ x 2-3/16″ x 2-5/8″; (pri 115v; 60 cyc; secd 20v at 0.25 amp; Wemco # L-406448.
RU	T-602	2Z9643.80	TRANSFORMER, IF: adjustable iron core, and variable air capacitor; zinc case; 4-1/4″ lg x 2-1/2″ wd x 4-3/4″ h; FW Sickles; Wemco # 7609773-G1.
DP	T-1901 T-1902	2Z9614-123	TRANSFORMER, power: voltage step and isolation; completely enclosed metal case; 2-13/16″ wd x 4-1/4″ lg x 4-1/8″ h; Wemco part # L-406758; 50v; 50/60 cyc pri; 200v 50 ma secd.
PCU	T-1301 T-1351	2Z9640-2	TRANSFORMER: impedance matching; 2-1/2″ x 2-7/8″ x 7-7/8″ h; cat. # 68G597; (pri 10v 60 cyc; to secd 2.35v at 0.105 amp; ratio 4.25 to 1.0; Wemco # L-406767).
PPR	T-1504	2Z9612.54	TRANSFORMER, power: plate; vacuum impregnated; hermetically sealed metal case; 3-5/8″ x 4-7/8″ x 4-27/32″; (pri 115v; 60 cyc; 0.0563 KVA; secd 900v CT; 0.0795 KVA); Wemco # L-386943.
FS	T-1153	2Z9612.34	TRANSFORMER, power: plate; vacuum impregnated; hermetically sealed metal case; 3-5/8″ x 5-1/8″ x 4-27/32″ (pri 115v; 60 cyc; 0.1414 KVA; secd 800v at 255 me; CT); Wemco # L-406449.
RU	T-601	2Z9643.79	TRANSFORMER, IF: plate load for xtal osc; 80 KC (adjustable iron core and variable air capacitor; 4-3/4″ h x 2-1/2″ wd x 2-5/16″ lg); FW Sickles; Wemco # 7609775-G1.
ReR	T-1001	2Z9612.35	TRANSFORMER, power: plate; vacuum impregnated, hermetically sealed metal case; 4-9/16″ x 6-1/4″ x 4-31/32″; (pri 115v; 60 cyc; secd 860v 325mc CT); Wemco # L-406427.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
ARR	T-2201	2Z9612.118	TRANSFORMER, power: plate; enclosed metal case; 4-9/16″ diam x 6-1/4″ wd x 4-27/32″ h; Wemco #L-426505-B; (pri 115v; 60 cyc; no taps; two secd windings 430v 0.163 amps for ea secd winding; four 13/32″ diam mtg holes, spaced on 2-1/2″ mtg centers; inserted on top of can a plastic term board 5-5/8″ x 4-3/16″ x 1/8″ thk, with five 0.136″ diam mtg holes for mtg of five hollow notched term).
PPR	T-1505	2Z9612.161	TRANSFORMER, power: plate; 5-3/16″ lg x 3-11/16″ wd x 7-1/8″ h; Wemco, L-spec 406407 F; Wemco dwg #T-7614147, part 684.
PPU	T-1601	2Z9611.113	TRANSFORMER, power: fil; vacuum impregnated; hermetically sealed metal case; 3-5/8″ x 4-7/8″ x 4-27/32″; (pri 115v; 60 cyc; 2 secd 6.3 v at 13 amp; 6.3v at 1.2 amp; Wemco #L-406437).
RaR	T-805	2Z9612.37	TRANSFORMER, power: plate; vacuum impregnated; hermetically sealed rectangular case; 3-3/4″ x 3-1/4″ x 4-1/8″; GE dwg #M7467171; (115v; 60 cyc; secd 2000v; 0.005 amp).
M	T-209	2Z9611.304	TRANSFORMER, power: fil; completely enclosed metal case; 4-1/4″ lg x 2-7/8″ wd; Wemco L. spec 406436; (pri 115v; 60 cyc; secd 2.5v; 10 amp).
M	T-208	2Z9611.104	TRANSFORMER, power: fil; metal case; 4-1/2″ x 2-3/4″ x 4-11/16″; (pri 115v 60 cyc; 2 secd 5.3v at 20.2 amp; 5.7v at 21.8 amp; 6 term); Wemco #L-406811.
FS PPR	T-1152 T-1501	2Z9611.114	TRANSFORMER, power: fil; vacuum impregnated; metal case; 4-3/4″ x 3-1/16″ x 3-7/8″ (pri 115v; 60 cyc; 0.030 KVA; 2 secd 5v 3 amp; 0.75 KV insulation); Wemco #L-386942.
ATU	T-502	2Z9611.80	TRANSFORMER, filament: 115v; 60 cyc; 2 secd 5v 3 amp; 6.3v 0.141 amps CT; vacuum impregnated; Wemco #L-406444.
SD	T-929	2Z9612.155	TRANSFORMER, power: plate; enclosed metal case; 2″ wd x 2-7/8″ h; Wemco #R-1382; (pri 115v; 60 cyc; secd #1 385v; 1.4 ma, secd #2 385v; 1.4 ma).
PI	T-1202	2Z9612.36	TRANSFORMER, power: plate; metal case; 2-1/2″ x 2-3/16″ x 2-5/8″; (pri 115v; 60 cyc; secd 230v at 0.001 amp CT); Wemco #L-406446.
CP	T-1755	2Z9613.391	TRANSFORMER, power: plate and fil; completely enclosed metal can; 2-1/2″ diam x 3-15/16″ lg; Wemco L. spec #426518; (pri 115v; 60 cyc; secd 6.3v; 1.2 amp CT and 600v 0.012 amp CT).

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
ReR ARR	T-1002 T-2203	2Z9613.311	TRANSFORMER, power: plate and fil; enclosed metal case; 3-1/16″ lg x 4-15/16″ wd x 4-19/32″ h; Wemco # L-406403; (pri 115v; 60 cyc; secd # 1 5v 0.011 amp CT; secd # 2 700v 0.011 amp; four 11/33″ diam mtg holes, spaced on 2″ mtg centers; insert on top of can a plastic term board 4-1/2″ x 3-1/4″ x 7/8″ thk; w/seven 0.136″ diam mtg holes spaced on 5/8″ mtg centers for mtg of 7 hollow notched term).
RaR	T-806	2Z9611.103	TRANSFORMER, power: fil; vacuum impregnated; metal case; 5-1/8″ x 3-5/8″ x 4-27/32″; (pri 115v; 60 cyc; 4 secd 6.3v, CT; 6.3v at 3 amp CT; 5v at 3 amp; 2.5 at 2 amp); Wemco # L-406405.
M	T-211	2Z9606.18	TRANSFORMER, power: fil; dimen 5-7/8″ x 5-11/32″ x 7-9/16″, on mtg/c 2-1/4″ x 2-3/4″; (pri 110/220v 60 cyc; 0.0378 KVA; secd 12.6v; 3 amp; 37,000v RMS; secd test 25,000 vdc; Wemco # L-406763).
ACR	T-1452	2Z9611.45	TRANSFORMER, filament: pri 115 v; 50 to 60 cyc; input 90 va; 2 secd 6.1v at 10 amp; 6.3v at 0.6 amp; metal case; 6-7/32″ h x 2-11/16″ x 4-19/32″; Wemco # KS-9872.
M	T-207	2Z9617-56	TRANSFORMER, power: fil; unshielded; 6-3/4″ lg x 5″ wd x 6-3/16″ h; Wemco, part/dwg # 7613612; (pri 115v; 55-65 cyc; secd 8v at 34 amp); Wemco # L-426504.
M	T-203 T-204	2Z9611.306	TRANSFORMER, power: fil; completely enclosed metal case; 7-3/4″ lg x 3-3/4″ wd x 12 3/16″ h; Wemco, part/dwg R-1432-C; Wemco # 7614147, part 673; (pri 115v; 60 cyc; secd 5 v; 6.5 amp.)
AETU	T-401 T-451	2Z9640-3	TRANSFORMER, matching: 60 cyc; ratio 1v pri to 20/10v, secd center tap; vacuum impregnated; Wemco # L-406756.
ACCU	T-1401 T-1402	2Z9879-2	TRANSFORMER, output: 210 cyc; to work out of 6SJ7 pentode impedance ratio 9.1; WECo # KS-8749.
ACR	T-1451	2Z9613.52	TRANSFORMER, power: pri 115v; 50 to 65 cyc; input 25 w; 4 secd windings; 5.1 v at 4.0 amp; 6.3v at 1.2 amp; 6.3v at 3.6 amp; secd 3-5 1,080v at 0.19 amp when connected to an inductively terminated full wave rectifier; WECo # K8-8878.
ACCU ACR	T-1403 T-1453	2Z9632.197	TRANSFORMER, power: output; pri 9v AC; 30.5 ohms; pri winding 1,512 turns of # 26 ga E wire; secd 67v, 9 w at 210 cyc; WECo # KS-9012.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
DU	T-101	2Z9613.77	TRANSFORMER, power: vacuum impregnated; hermetically sealed metal case; 3-3/8″ x 2-5/8″ x 4″; GE dwg #7467137; (pri 115v; 1.9 amp; 0.0215 kva; 2 secd; 350v; 0.026 amp; 0.024 kva; 5v; 3 amp); Wemco #L-406408.
DU	T-105	2Z9627-36	TRANSFORMER, power: pulse; vacuum impregnated; over-all dimen including mtg; 3-13/16″ x 2-3/8″ x 4-9/32″ on 1-7/8″ mtg/c; (pri impedance 18,000 ohms; 3,600v peak; 60 cyc; 20 ma; AC; secd impedance 18,000 ohms; 3,600v peak; 20 ma; AC; 35 ma; DC); Wemco #L-421740.
LO	T-1801	2Z9613.80	TRANSFORMER, power: vacuum impregnated; hermetically sealed metal case; 3-5/8″ x 3-1/8″ x 4-27/32″; (pri 115v; 60 cyc; 0.080 kva; 3 secd; 500v tapped at 300v; 0.100 amp; 5v; 3 amp; 30 amp; Wemco #L-406433).
RaR PPR	T-804 T-1502	2Z9612.38	TRANSFORMER, power: plate; vacuum impregnated; hermetically sealed metal case; 3-5/8″ x 5-1/8″ x 4-27/32″ (pri 115v; 60 cyc; secd 900v at 225 ma CT; 0.143 kva); Wemco #L-406401.
DU	T-102	2Z9612.74	TRANSFORMER, power: vacuum impregnated; metal case; 3-3/4″ x 3-1/4″ x 5″; GE dwg #M7467118; (pri 115v; 60 cyc; 0.35 amp; 2 secd 400-0-400; 0.063 amp; 50 va; 225-0-225v; 0.013 amp; 6 va); Wemco #L-406409.
M	T-210	2Z9612.73	TRANSFORMER, power: plate; schematic #T-214; vacuum hermetically sealed metal case; 6-7/8″ x 4-5/32″ x 6-13/16″; GE dwg #M 7467808; (pri 115v; secd #1; 2,700v; 0.081 amp CT, secd #2; 2,530v; 0.075 amp; secd #3; 2,360v; 0.070 amp; secd #4; 2,190 v; 0.065 amps; secd #5; 2,020v; 0.060 amp; secd #6; 1,850v; 0.050 amp).
M	T-202	2Z9612.154	TRANSFORMER, power: plate; completely enclosed metal case; 13″ lg x 10-1/4″ wd x 18-1/8″ h; Wemco dwg/part R-1474; Wemco dwg #7614147, part 672; (pri 115v; 60 cyc; secd 9,650v; 0.050 amp).
OPS	T-951	2Z9627-13	TRANSFORMER, pulse: unshielded; 1-9/16″ wd x 1-9/16″ h x 1-5/8″ lg; 3 windings each 150 ohms impedance; Wemco #145EW; Wemco dwg #T-7614148, part 711.
DU	T-104	2Z9636.22	TRANSFORMER, power: pulse inter stage; vacuum impregnated; hermetically sealed steel case; 2-1/8″ h x 2-1/4″ lg x 1-7/8″ wd; 1,800v; 60 cyc; 2 ma; secd 1,200v; 0.5 ma; Wemco #L-406439.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
RaR	T-802 T-803	2Z9621-16	TRANSFORMER, power: step-down; vacuum impregnated; hermetically sealed rectangular metal case; 3-1/16″ x 4-3/4″ x 3-7/8″; (input 250v; 60 cyc; 0.091 kva; output 125v; 0.091 kva; 0.725 amp); Wemco # L-386947.
M	T-206	2Z9613.116	TRANSFORMER, power: tapped; vacuum impregnated; hermetically sealed metal case; 9-1/2″ x 5-23/32″ x 7″; (pri 115v; 60 cyc; tapped; secd 200v; 0.5 kva; CT 5,400v at 0.38 kva CT); Wemco # L-386948.
RU	T-603	2Z9621-30	TRANSFORMER, step-down: pri 75v; 0.05 amp; secd 15v at 0.17 amp; vacuum impregnated; hermetically sealed metal case 1-3/8″ x 1-1/8″ x 2-5/16″; Wemco # L-406441.
PA	T-1852	2Z9643.64	TRANSFORMER, IF input: adjustable iron core tuning; dimen 1-1/2″ lg x 1/4″ center diam; screwdriver adjusted; Wemco # 7408520-G1.
ARU	T-2105	2Z9611.249	TRANSFORMER, power: fil; enclosed metal case; 3-1/2″ OD x 4-1/2″ h x 0.025″ thk; Wemco # L-423190-B; (pri 115v; 60 cyc; secd # 1, 6.3v; 3 amp; secd # 2, 6.3v; 3 amp; secd # 3, 6.3v; 3 amp; secd # 4, 6.3v; 3 amp).
ARR	T-2202	2Z9611.266	TRANSFORMER, power: fil; enclosed metal case; 3-1/2″ diam x 4-1/2″ h x 0.025″ thk; Wemco # L-426501; (pri 115v; 55/65 cyc; three-secd winding; secd # 1, 6.3v; 3 amp; secd # 2, 6.3v; 3 amp; CT; secd # 3, 5v; 3.8 amp; term board inserted on top of can isolantite 3/16″ thk x 3-7/16″ diam w/nine 0.154″ diam of mtg holes 45° apart for mtg of nine hollow notched term; 13/32″ x 0.25″ diam; fish-paper insulation to fit around core and coil.
RI	T-902 T-903	2C1557-1088B/C1	TRANSFORMER ASSEMBLY; tuned impedance matching circuit; 10 turns pri, 1,060 turns secd; includes two resistors and three fixed capacitors; adjustable powdered iron core tuning; metal can 3-3/4″ h x 2-1/2″ wd x 2-1/2″ d; FW Sickles; Wemco # 7609841-G1, G3.
DU	T-103	2Z9611.105	TRANSFORMER, power: fil; vacuum impregnated; hermetically sealed metal case; 3-5/8″ x 5-1/8″ x 4-27/32″; GE dwg # M7467111; (pri 115v; 60 cyc; 0.84 kva; 3 secd; 6.3v at 8.5 amp; 5v at 3 amp); Wemco # L-406402.
SD	T-928	2Z9614-120	TRANSFORMER, power: control; inclosed metal can; 3-3/8″ wd x 5-1/8″ lg x 4-1/2″ h; Wemco R-spec # 1377-B; pri 115v; 60 cyc; secd 150v 170 ma ac; 75 ma dc; 150v 170 ma ac; 75 ma dc; and 85v 45 ma ac; w/15, 20, 30, and 50v taps.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
ReR	T-1003	2Z9611.106	TRANSFORMER, power: fil; vacuum impregnated; hermetically sealed metal case; 3-5/8″ x 5-1/8″ x 4-27/32″; (pri 115v; 60 cyc; 2 secd; 5v at 6 amp; 6.3v at 8 amp; Wemco #L-406404).
M	T-205	2Z9611.109	TRANSFORMER, power: fil; vacuum impregnated; hermetically sealed case; 3-5/8″ x 5-1/8″ x 4-27/32″ (pri 115v; 60 cyc; 0.065 kva; secd 5v at 13 amp; 3/25 kv insulating); Wemco #L-406435.
RaR	T-801	2Z9611.111	TRANSFORMER, power: fil; vacuum impregnated; hermetically sealed metal case; 3-5/8″ x 5-1/8″ x 4-27/32″; (pri tapped at 33.3, 60.4, 66.7, 83.3, 115, 116.7 and 113.3v; 3 secd, ea 5v at 0.015 kva; CT); Wemco #L-406400.
LO PA	T-1802 T-1851	2Z9611.110	TRANSFORMER, power: fil; vacuum impregnated; hermetically sealed metal case; 2-1/2″ x 3-1/4″ x 3-23/32″; pri 115v; 60 cyc; 0.0945 kva; secd 6.3v at 1.5 amp; 75 kv insulation; Wemco #L-406434.
PPR	T-1506	2Z9611.112	TRANSFORMER, power: fil; vacuum impregnated; hermetically sealed metal case; 3-1/16″ x 4-1/2″ x 4-5/16″; 115v; 60 cyc; 0.005 kva; secd 2.5v; 2 amp; Wemco #L-386946.
PPR	T-1503	2Z9611.81	TRANSFORMER, power: fil; vacuum impregnated; hermetically sealed metal case; 3-1/16″ x 4-3/4″ x 4-15/32″; pri 115v; 60 cyc; 0.0227 kva; secd #1, 6.3v at 0.6 amp; secd #2, 6.3v, CT at 3 amp; Wemco #L-406438.
PI	T-1201	2Z9611.107	TRANSFORMER, power: fil; metal case; 3-1/4″ x 2-1/2″ x 3-23/32″; pri 115v; 60 cyc; 0.0315 kva; secd 6.3v, 5 amp; Wemco #L-406442.
SD	T-927	2Z9636.83	TRANSFORMER, power: grid phasing; inclosed metal case; 2-1/2″ diam x 3-1/4″ lg; Wemco dwg/part #L-423192; pri 115v; 60 cyc; secd 43v and 43v.
CP	T-1751 thru T-1754	2Z9611.320	TRANSFORMER, power: fil; not shielded; 3-5/16″ lg x 2-5/16″ wd x 2-1/4″ h; GE cat. #74-G-657; Wemco dwg #7408545, part 1.
RI	T-904 T-905	2C1557-1088B/C2	TRANSFORMER ASSEMBLY: tuned impedance matching; adjustable powdered iron core; includes two resistors and three fixed capacitors; pri 20 turns; secd 6,640; FW Sickles; Wemco #7609774-G1, G3.
M	T-201	2Z9621-94	TRANSFORMER ASSEMBLY, AF: consisting of one transformer O-135v output; motor driven; 2 kva; 115v input; three SPST norm open switches; one SPST norm closed switch; over-all dimen 9″ lg x 8-1/2″ wd x 10-3/4″ d; Wemco #7613594-G1.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
SD	T-926	2Z9611.305	TRANSFORMER, power: fil; inclosed metal case; 3″ diam x 4-3/16″ lg over-all; 115v; 60 cyc; secd 6.3v; 0.3 amp; 6.3v; 0.3 amp; 6.3v; 0.3 amp; 6.3v; 0.6 amp; 6.3v; 0.6 amp.
RI	T-901	2Z9611.79	TRANSFORMER, power: fil; hermetically sealed metal case; 2-1/2″ x 2-3/16″ x 3″; pri 115v; 60 cyc; 0.0078 kva; secd 6.5v; 1.2 amp; Wemco # L-406757.
ATU	T-501	2Z9640-4	TRANSFORMER, power: matching; feeds error voltage selsyn motor; vacuum impregnated; hermetically sealed metal case; 3″ h x 2-1/2″ lg x 2-3/16″ wd; voltage and amps vary; ratio 1.4/2; CT; Wemco # L-406754.
R	T-701 T-702	2Z9613.79	TRANSFORMER, power: upright metal case; 4-3/4″ x 3-1/16″ x 3-7/8″; GE dwg # 7467164; pri 115v; 60 cyc; secd 6.3v; 1 amp CT; 1,600v, CT; 10 ma; Wemco # L-406419.
TrL	T-1977 T-1978	2Z9614-118	TRANSFORMER, power: for p/line regulator; 5-3/4″ h x 6-5/8″ wd x 6-5/8″ lg; Superior Elec type # S66P, style EA-3061; Wemco dwg # 7614147, part 668; pri 63v; 50/60 cyc; secd 15v; 66 amp.
RI	VR-901	2Z9957-16	TRANSFORMER, variable, power: auto transf; transtat; GE # 100Q; variable input 115v; 60 cyc; 2,000 w; output 0 to 135v ac; current rating 18 amp; hex shape; 7″ diam x 9″ h behind panel 3/8″ thk; wheel pointer and voltage indicator on front.
TrL	T-1976	2Z9614-121	TRANSFORMER, power: voltage regulator; auto transf; 10-1/2″ x 10-1/2″ x 18-1/2″ lg; Superior Elec type # S666P, style EP-3061; Wemco dwg # 7614147, part 667; pri 115v; 50/60 cyc; secd 46v to 0 to 69v at 18 amp per unit.
		2Z10009-14	TRANSMISSION LINE: I-J assem; LH Terpening # C-270-232.
		2Z10009-15	TRANSMISSION LINE: J-K assem; LH Terpening # B-270-243; HS Joint-Rear Sect.
		2Z10009-16	TRANSMISSION LINE: K-L assem; LH Terpening # C-270-259.
		2C6596-1373	TRANSMITTER, frame assembly: BC-1373; (modulator HV rectifier and transmitter); Wemco # DL-7502953-G1.
		2J6AC7	TUBE, electron: JAN-6AC7 (VT-112).
		2J6SK7G	TUBE, electron: JAN-6SK7GT/G (VT-117A).
		2J6SL7GT	TUBE, electron: JAN-6SL7GT (VT-229).

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
		2J6SN7GT	TUBE, electron: JAN-6SN7GT (VT-231).
		2J6L6G	TUBE, electron: JAN-6L6G (VT-115V).
		2J6H6	TUBE, electron: JAN-6H6 (VT-90).
		2J6AG7	TUBE, electron: JAN-6AG7 (VT-247).
		2J6SJ7GT	TUBE, electron: JAN-6SJ7GT (VT-116A).
		2JOC3/VR105	TUBE, electron: JAN-OC3/VR 105 (VT-200).
		2J5U4G	TUBE, electron: JAN-5U4G (VT-244).
		2J6B4G	TUBE, electron: JAN-6B4G.
		2J83	TUBE, electron: JAN-83 (VT-83).
		2J2x2	TUBE, electron: JAN-2x2 (VT-119).
		2J1616	TUBE, electron: JAN-1616 (VT-266).
		2J3DP1	TUBE, electron: JAN-3DP1.
		2J7BP7	TUBE, electron: JAN-7BP7.
		2J3E29	TUBE, electron: JAN-3E29.
		2J8020	TUBE, electron: JAN-8020 (VT-267).
		2J721A	TUBE, electron: JAN-721A.
		2J6C21	TUBE, electron: JAN-6C21.
		2J2J31	TUBE, electron: JAN-2J31 (VT-251).
		2J2J32	TUBE, electron: JAN-2J32 (VT-251).
		2J2J33	TUBE, electron: JAN-2J33 (VT-251).
		2J2J34	TUBE, electron: JAN-2J34 (VT-251).
		2J417A	TUBE, electron: JAN-417A.
		2J2050	TUBE, electron: JAN-2050 (VT-245).
		2J6x5GT/G	TUBE, electron: JAN-6x5GT/G (VT-126B).
M	CR-201	2JIN21B	TUBE: xtal; rect; RMA type IN21B; WECo spec # D-169113; Philco # 455-1055.
		2C1557-1058C	UNIT, plan position: BC-1058-C; Wemco # DL-7502466-G2.
		3H4496-132	UNIT, power supply: RA-132; (automatic range tracking unit); Wemco # DL-7502886-G2.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
		2Z3775-3	VALVE, intake: compressor; Dielectric dwg #AD-25-5.
		2ZA800	VALVE, solenoid: Dielectric dwg #AD-27-2.
		6L51736	WASHER, lead: for check valve; over-all dimen 1-3/16" OD x 1" ID x 1/32" thk; Dielectric Prod part/dwg #AD-24-3; Wemco dwg #7416899, part 19.
		6L58402-2C	WASHER: special; steel; 15/16" OD x 12/16" ID; 3/16" thk; 3/32" flange; hole through center 5/32" diam; Palmer-Bee Co; PC 208-173-C; Wemco dwg #M-7417540, part 44.
		6L73653P	WASHER, bowed: steel; 9/32" OD x 3/16" ID x 1/64" thk; Palmer-Bee Co RI 101-262; Wemco dwg #M-7417540, part 39.
		6L73652P	WASHER, bowed: steel; 9/32" OD x 1/8" ID x 1/128" thk; Palmer-Bee RI 107-277-C; Wemco dwg #M-7417540, part 40.
		6L54102	WASHER, rubber: Palmer-Bee PI 307-318-C; Wemco dwg #M-7417540, part 1.
		1B810-12	WIRE, copper: 3 #10 AWG cond; stranded; rubber insulated; type S.
		1B810.31	WIRE, insulated: copper, annealed and tinned; single #10 AWG stranded cond; 105 #30 strands; 0.18" OD; cellulose butyrate tapes insulation; covered 2 braids glass yarn; Wemco PD spec #8026-5.
		1B812.51	WIRE, insulated: copper, annealed and tinned; single #12 AWG stranded cond; 65 #30 strands; 0.16" OD; cellulose butyrate tapes insulation; covered 2 braids glass yarn; Wemco PD spec #8026-5.
		1A814.10	WIRE: bus; #14 AWG; bare: solid, tinned copper; SD; Wemco #PDS2003-8.
		1B814.131	WIRE, insulated: copper, annealed and tinned; single #14 AWG stranded cond; 41 #30 strands; 0.14" OD; cellulose butyrate tapes insulation; covered 2 braids glass yarn; Wemco PD spec #8026-5.
		1B816.129	WIRE, insulated: copper, annealed and tinned; single #16 AWG stranded cond; 26 #30 strands; 0.12" OD; cellulose butyrate tapes insulation; covered 2 braid glass yarn; Wemco PD spec #8026-5.

358. MAINTENANCE PARTS LIST FOR RADIO SET SCR-784 LESS PEDESTAL MP-61-B.

Major component	Reference symbol	Signal Corps stock No.	Name of part and description
		1A818.1	WIRE, copper: #18 AWG; tinned; Wemco #PD S2003-2.
		1B1320.9	WIRE: stranded #20 AWG white; FW Sickles KS-8640.
		1B3020-2.13	WIRE, insulated: copper; 2 #20 cond stranded 26 #34; 1/4″ OD; color-coded white and black; rubber insulated; 1/64″ single shielded; Venyl jacket over-all; Gencable; Wemco dwg# 7614153 part 997.
		1B1322.7	WIRE, insulated: copper, tinned; single #22 AWG stranded 7 #30 strands; 0.089″ OD; 1 cotton braid; code rubber; Wemco PD spec #6439-2.
		1B822.3	WIRE, insulated: copper; #22 AWG stranded; 7 strands; 0.05″ OD; no tracers; cotton braid; Lenz; Wemco dwg #7614153-953.
		1B808.1	WIRE, insulated: copper; single #8 stranded cond; 3/4″ OD; black rubber insulation 1/4″ thk; covered with red rubber 1/16″ thk; Okonite Okoprene 20 kv; Wemco dwg #7614153, part 965.
		1B808.5	WIRE: flexible #8 AWG 3 cond; stranded; 600v; Simplex type S (cord RC).

SECTION II

MAINTENANCE PARTS LIST FOR PEDESTAL MP-61-B

359. INDEX.

360. MAINTENANCE PARTS LIST FOR PEDESTAL MP-61-B.

Signal Corps Stock No.	Name of Part and Description
2A2704-61B	PEDESTAL MOUNT: complete; MP-61-B.
3E7204-3	CABLE AND PLUG ASSEMBLY: azimuth base; one contact plug and cable; Chrysler #1070340.
1B3015-22	CABLE: G. E. type CW-1273; Navy spec. 15C1 (22 cond.)
1B3015-10	CABLE: G. E. type CW-1273; Navy spec. 15C1 (10 cond.).
1B3020-7.1	CABLE: #20 stranded; 7 cond.; G. E. type MCS-7; Navy spec. 16C1.
1B816.31	WIRE: black; #16, MS-882; Chrysler #211320-RS.
3E7204-5	WIRING HARNESS, ASSEMBLY: azimuth motor; Chrysler #1070326.
2A2704-61B/H2	WIRING HARNESS, ASSEMBLY: azimuth potentiometer; Chrysler #1070351.
3E7204-1	WIRING HARNESS, ASSEMBLY: elevator drive motor; Chrysler #1070331.
2A2704-61B/H1	WIRING HARNESS, ASSEMBLY: elevator potentiometer; Chrysler #1070350.
3E7204	WIRING HARNESS, ASSEMBLY: spinner motor and generator; Chrysler #1070335.
2A2704-61B/C4	WIRING HARNESS, ASSEMBLY: azimuth base; 8-contact plug; Chrysler #1070338.
2A2704-61B/C5	WIRING HARNESS, ASSEMBLY: azimuth base; 12-contact plug; Chrysler #1070337.
2A2704-61B/C2	WIRING HARNESS, ASSEMBLY: azimuth base; 22-contact plug; Chrysler #1070339.
2A2704-61B/C3	WIRING HARNESS, ASSEMBLY: azimuth base; 8-contact socket; Chrysler #1070336.
2A2704-61B/C9	WIRING HARNESS, ASSEMBLY: azimuth base; 22-contact socket; Chrysler #1070333.
3G1838-97	INSULATOR: azimuth base; receptacle plate term. strip; Chrysler #106648.
2A2704-61B/S36	INSULATOR: slip-ring; Chrysler #1066214.
3Z9508	SWITCH: azimuth base; safety; Chrysler #1066317.
3Z9558.1	SWITCH: azimuth main shaft; stowing; Chrysler #106638.
3Z9558-24	SWITCH: azimuth; stowing; Chrysler #1066322 schem. #V-7.
3Z9508	SWITCH: toggle; 6 amps., 250 volts; DPST; 12 amps., 125 volts.
2A2704-61B/S11	SOCKET: socket and plate assembly; telescope light; Chrysler #1066521.
2ZK7409-21	SOCKET: female; 22 contact; type AN-3102-36-1S.
2Z8671.27	SOCKET: female; 1 contact; type AN-3108-14S-4S; Monowatt.

360. MAINTENANCE PARTS LIST FOR PEDESTAL MP-61-B.

Signal Corps Stock No.	Name of Part and Description
2Z8682.8	SOCKET: female; 12 contacts; type AN-3108-28-8S; Monowatt.
2Z8678.44	SOCKET: female; 8 contacts; type AN-3108-20-7S; Monowatt.
2Z8678.68	SOCKET: 20 contacts; type AN-3102-20-7S.
2Z8799-184	SOCKET: 22 contacts; type AN-3102-36-1P.
2Z9412.42	TERMINAL BOARD: 12 term.; G. E. #ML-7893799-G1.
3Z12073-6	TERMINAL: brass; Chrysler #150830.
3Z12076.11	TERMINAL: brass; Chrysler #114039.
3Z12073-6.1	TERMINAL: brass, 2-wire type; Chrysler #114052.
3Z12073-6.2	TERMINAL: copper; Chrysler #676915.
3G1838-128.1	TERMINAL BLOCK: azimuth base; term. strip mtg.; Chrysler #1066447.
2A2704-61B/B3	TERMINAL BLOCK: azimuth base; 12-point rec. mtg.; Chrysler #1066577.
3G1838-9	TERMINAL STRIP: elevation; Chrysler #1066448.
2Z9412.8	TERMINAL STRIP: azimuth base; 12-point terminals; Chrysler #1066452.
2ZK7132-4	PLUG: male; 22 contacts; type AN-3108-36-1P; Monowatt.
2Z7226-Q244	PLUG: female; 22 contacts; type AN-3108-36-1S; Monowatt.
2Z7111.59	PLUG: male; 1 contact; type AN-3100-14S-4P.
2Z7118.22	PLUG: 8 contacts; type AN-3102-20-7P.
2Z7118.21	PLUG: male; 8 contacts; AN-3108-20-7P; Monowatt.
2Z7122.2	PLUG: male; 12 pins; type AN-3102-28-8P.
2A2704-61B/S14	ASSEMBLY: azimuth; selsyn drive shaft; Chrysler #1061700.
2A2704-61B/S13	ASSEMBLY: azimuth; selsyn drive shaft handle and stem; Chrysler #106623.
2A2704-61B/G22	ASSEMBLY: azimuth; selsyn generator, final drive pinion; Chrysler #1061758.
2A2704-61B/G35	ASSEMBLY: azimuth; sun gear; Chrysler #1066158.
2A2704-61B/G36	ASSEMBLY: elevation bell; potentiometer gear; Chrysler #1066588.
2A2704-61B/G38	ASSEMBLY: elevation; drive annulus gear and shaft; Chrysler #1066260.
2A2704-61B/P9	ASSEMBLY: elevation drive; oil pump body; Chrysler #1066496.
2A2704-61B/M1	ASSEMBLY: elevation; limit switch mounting, partial plate; Chrysler #1061761.
2A2704-61B/G21	ASSEMBLY: elevation; selsyn idler gear; Chrysler #1066341.

Signal Corps Stock No.	Name of Part and Description
2A2704-61B/T1......	ASSEMBLY: elevation; selsyn tube and flange gear housing; Chrysler #1066368.
2A2704-61B/C16.....	ASSEMBLY: elevation stowing; switch contact plate; Chrysler #1066427.
2A2704-61B/R1.....	ASSEMBLY: hem "P" painted; Chrysler #1061766.
2A2704-61B/B2......	ASSEMBLY: for adjusting screw base; Chrysler #1066394.
2A2704-61B/P2......	ASSEMBLY: housing panel; azimuth control; Chrysler #1066382.
2A2704-61B/P3......	Superseded by #1061580.
2A2704-61B/B8......	ASSEMBLY: slip-ring contact block; Chrysler #1066367.
2A2704-61B/S3......	ASSEMBLY: slip-ring contact brush arm; Chrysler #1066357.
2A2704-61B/S1......	ASSEMBLY: spinner motor; housing seal; Chrysler #1066497.
2A2704-61B/S10.....	ASSEMBLY: spinner motor; seal sleeve; Chrysler #1061795.
2A2704-61B/B7......	ASSEMBLY: telescope mounting bracket; Chrysler #106178.
2A2704-61B/B1......	BALL: steel; ¼"; Chrysler #147485; azimuth oil pump reg.
3H250..............	BALL: steel; ½"; Chrysler #147493.
3H320-40...........	BEARING: azimuth annulus gear (large); Chrysler #1066146.
3H1915-1/B20.......	BEARING: azimuth selsyn drive shaft; Chrysler #1066176.
3H320-39...........	BEARING: azimuth selsyn drive shaft sleeve; Chrysler #1066168.
3H310-10...........	BEARING: azimuth annulus gear (small); Chrysler #619288.
3H320-38...........	BEARING: elevation drive; main gear hub; Chrysler #1066239.
3H307-3............	BEARING: elevation selsyn drive shaft; Chrysler #1066240.
3H307-2............	BEARING: spinner motor; Chrysler #1066235.
3G1838-42.6.........	BLOCK: azimuth base; one point receptacle mtg.; Chrysler #1066576.
2A2704-61B/B4......	BLOCK: azimuth motor drive coupling; Chrysler #1066229.
2A2704-61B/B6......	BRACKET: elevation terminal strip; Chrysler #1066332.
3H510..............	BRUSHES: for motor; model BC-46AB772 or #5BC-46AB857.
2A2704-61B/C10.....	CAM: elevation limit switch; Chrysler #1066306.
2A2704-61B/C7......	CAM: elevation limit switch mounting plate; Chrysler #1066305.
2A2704-61B/C6......	CAM: oil pump; Chrysler #1066147.
2A2704-61B/C14.....	CLAMP: azimuth; selsyn generator; Chrysler #1066455.
2A2704-61B/C15.....	CLAMP: azimuth; selsyn transformer; Chrysler #1066618.

Signal Corps Stock No.	Name of Part and Description
2A2704-61B/C13	CLAMP: elevation selsyn; Chrysler #1066428.
2A2704-61B/C18	COUPLING: azimuth motor drive; Chrysler #1066228.
2A2704-61B/C17	COUPLING: azimuth potentiometer; Chrysler #1066289.
2A2704-61B/C22	COVER: elevation drive case; Chrysler #1066575.
2A2704-61B/C19	COVER: elevation yoke; Chrysler #1066330.
2A2704-61B/C2	COVER: spinner motor and generator housing; Chrysler #1066437.
6L3943-6-1	DOWEL PIN: azimuth oil pump can; Chrysler #141149. (See item SCR584B/16-182).
6L3941-7	DOWEL PIN: 1/16″ dia. x 7/16″ long; Chrysler #141053.
6L3943-6-1	DOWEL PIN: 3/16″ dia. x 3/8″ long; Chrysler #141149.
6L3944-6	DOWEL PIN: 1/4″ dia. x 3/8″ long; Chrysler #103734.
6L3945-6	DOWEL PIN: 5/16″ dia. x 3/8″ long; Chrysler #141213.
6Z3661-4.3	ELBOW BRASS: 1/8″ standard 90°; Chrysler #137421.
6Z3661-4.3	ELBOW: 90°; elevator drive oil pump tube; Chrysler #137421.
6Z3410-2	ENTRANCE: elevation cable; Chrysler #1066319.
2A2704-61B/R3	FELT: azimuth selsyn drive shaft; Chrysler #1066174.
2A2704-61B/F1	FLANGE: spinner motor driving; Chrysler #1066458.
2A2704-61B/G31	GASKET: azimuth control housing panel cover; Chrysler #1066391.
2A2704-61B/G32	Replaced with #1061531.
2A2704-61B/G9	GASKET: azimuth motor; Chrysler #1061775.
2A2704-61B/G15	GASKET: azimuth oil pump reg. spring SC; Chrysler #106617.
2A2704-61B/G11	GASKET: azimuth oil reservoir and cover; Chrysler #1066185.
2A2704-61B/G10	GASKET: azimuth; selsyn drive shaft hub; Chrysler #1066610.
2A2704-61B/G16	GASKET: elevation drive oil pump body; Chrysler #1066487.
2A2704-61B/G15	GASKET: elevation drive; oil pump; pressure spring SC; Chrysler #1066617.
2A2704-61B/G39	GASKET: elevation; selsyn gear housing cover; Chrysler #1066219.
2A2704-61B/G29	GASKET: elevation; yoke cover; Chrysler #1066331.
2A2704-61B/G6	GASKET: elevator drive; case cover; Chrysler #1066574.
2A2704-61B/G26	GASKET: elevator; telephone jack housing; Chrysler #929373.
2A2704-61B/G28	GASKET: housing panel; azimuth control; Chrysler #1066386.

Signal Corps Stock No.	Name of Part and Description
2A2704-61B/G30	GASKET RING: azimuth control; housing frame; Chrysler #1066626.
2A2704-61B/G14	GASKET: slip-ring; brush terminal board cover; Chrysler #1066429.
2A2704-61B/G4	GASKET: spinner motor and generator housing cover; Chrysler #1061726.
2A2704-61B/G25	GASKET: spinner motor and generator shaft; seal nut; Chrysler #1061763.
2A2704-61B/G3	GASKET: spinner motor; housing seal; Chrysler #1066502.
2A2704-61B/G27	GASKET: spinner motor; rear flange; Chrysler #1061603.
2A2704-61B/G13	GASKET: spinner motor; terminal strip cover; Chrysler #1061710.
2A2704-61B/G12	GASKET: telescope; light socket; Chrysler #1066524.
2A2704-61B/G5	GASKET: telescope; light socket plate; Chrysler #1066523.
2A2704-61B/G20	GEAR: azimuth; selsyn generator; Chrysler #1066597.
2A2704-61B/G19	GEAR: azimuth; selsyn generator; final drive; anti-backlash; Chrysler #1061760.
2A2704-61B/G18	GEAR: azimuth; selsyn transformer; Chrysler #1066598.
2A2704-61B/G24	GEAR: azimuth; selsyn transformer; anti-backlash; Chrysler #1066600.
2A2704-61B/G2	GEAR: azimuth; stationary annulus; Chrysler #1066161.
2A2704-61B/G1	GEAR: elevation; selsyn generator driven (1:1); Chrysler #1066602.
2A2704-61B/G23	GEAR: elevation; selsyn transformer drive; Chrysler #1066601.
3H2411-8	GENERATOR: selsyn; variable voltage input, 105 volts 60 cycles, max. variable voltage, output single phase, 0 to 55 volts; G. E. model #2J5FB1.
3H2411-6	GENERATOR: selsyn; variable voltage input, 115 volts, 60 cycles; G. E. model #2J5HA1.
2A2704-61B/K3	KEY: azimuth; drive gear (red); Chrysler #1061729.
2A2704-61B/K4	KEY: azimuth; drive pinion (white); Chrysler #1061733.
6L996-44B	KEY: azimuth; main drive gear (blue); Chrysler #1061731.
6L996-44W	KEY: azimuth; main drive gear (white); Chrysler #1061730.
2A2704-61B/K2	KEY: azimuth; main drive pinion (red); Chrysler #1061732.
6L995-3	KEY: azimuth; potentiometer coupling; Chrysler #106749.
2A2704-61B/K1	KEY: azimuth; selsyn drive shaft; Chrysler #1066349.
6L996-6	KEY: azimuth; selsyn generator gear; Chrysler #1066612.
6L996-11	KEY: elevation; bell potentiometer gear; Chrysler #1066375.
6L996-4	KEY: spinner motor; driving flange; Chrysler #1066418.

360. MAINTENANCE PARTS LIST FOR PEDESTAL MP-61-B.

Signal Corps Stock No.	Name of Part and Description
6L995-3	KEY: Woodruff #3⅛" x ½"; Chrysler #106749.
6L995-5	KEY: Woodruff #5⅛" x ⅝"; Chrysler #103905.
6Z6814-6	LAMP: telescope; double bayonet; type G6.
3H321-7	LAYOUT: azimuth; main drive shaft bearing (lower); Chrysler #1066198.
3H321-8	LAYOUT: azimuth; main drive shaft bearing (upper); Chrysler #1066210.
6Q63165	LEVEL: elevation yoke; Chrysler #1066430.
2A2704-61B/P6	LOCK: plate elevator screw; Chrysler #928245.
3H3100A75-2	MOTOR: 115 volts, 60 cycles, 3-phase, 1,725/150 r.p.m., ¾ h.p.; G. E. type #K-063128.
3H3100ASD-2	MOTOR: 250 volts, d-c armature, ½ h.p., 300 volts, d-c; G. E. model #4BC-46AB857.
2A2704-61B/N5	NUT: clamping; azimuth main drive shaft; powerline; Chrysler #1066578.
6L3604-40	NUT: hex. #4-40; Chrysler #134524.
6L3606-40	NUT: hex. #6-32; Chrysler #134530.
6L3324-20	NUT: wing; brass #¼-20; packed in cloth bag F70C1B (cap plate) Parker Kalon.
6L3506-16-9	NUT: hex. #⅜-16; Chrysler #120377.
6L3506-24-64S	NUT: #⅜-24; Chrysler #120369 (hex).
6L3507-20.3	NUT: hex. #7/16-20; Chrysler #124929.
6L3508-13-12.3	NUT: hex. #½-13; Chrysler #120238.
6L3508-20.3	NUT: hex. #½-20; Chrysler #120371.
2A2704-61B/N1	NUT: spinner; motor; lock; Chrysler #1066480.
2A2704-61B/N4	NUT: spinner; motor generator shaft seal; Chrysler #106176.
2A2704-61B/N3	NUT: azimuth; main drive shaft bearing; Chrysler #1066215.
2A2704-61B/N2	NUT: azimuth; selsyn drive shaft lock; Chrysler #106618.
6L3690-8S	NUT: base adjustment; screw lock; Chrysler #1066397.
6L3946-19	PIN: azimuth; stowing lock; Chrysler #1066633.
6L3904-18C	PIN: grooved ¼" x 1 1/16"; Chrysler #144563.
6L3944-9	PIN: slip-ring support; Chrysler #1066362.
2Z4871-74	PINION: elevation; selsyn generator drive (16:1); Chrysler #166603.
2A2704-61B/P5	PLATE: azimuth base; receptacle mounting; Chrysler #1066581
3Z4150-6	PLATE: azimuth; main shaft stowing switch; adjustment; Chrysler #1061777.

Signal Corps Stock No.	Name of Part and Description
2A2704-61B/P10.....	PLATE: azimuth; selsyn adjustment pinion; Chrysler #1066507.
2A2704-61B/P1......	PLATE: mounting; elevation yoke level; Chrysler #106648.
2Z7586-6.5..........	PLUG: pipe; countersunk; headless ½"-14; selsyn gear housing; Chrysler #144014.
6Z7586-15...........	PLUG: pipe; magnetic; hex. head ⅞"-18; Chrysler #1061770.
6Z7586-6.3..........	PLUG: pipe; magnetic; square head ½"; Chrysler #1061769.
6Z7586-2.5..........	PLUG: slotted; headless pipe ⅛"-27; Chrysler #125947.
6Z7586-6.6..........	PLUG: pipe; square head ½"-14; Chrysler #143935.
2A2704-61B/P7......	PLUNGER: azimuth oil pump; Chrysler #1066509.
2A2704-61B/P8......	PLUNGER: elevation drive; oil pump; Chrysler #1066302.
2A2704-61B/R16.....	RETAINER: Chrysler #1066173.
2A2704-61B/R6......	RETAINER: azimuth oil pump; plunger spring; Chrysler #1066510.
2A2704-61B/R4......	RETAINER: elevation drive; oil pump plunger spring; Chrysler #1066301.
2A2704-61B/R7......	RETAINER: spinner; motor generator bearing; Chrysler #1066466.
2A2704-61B/R5......	RETAINER: spinner; motor housing seal spring; Chrysler #1066500.
2A2704-61B/R10.....	RING: azimuth annulus gear; bearing snap; ext. thin; Chrysler #1061776.
2A2704-61B/R9	RING: azimuth annulus gear; bearing snap; medium; Chrysler #1066276.
2A2704-61B/R8......	RING: azimuth annulus gear; bearing snap; thick; Chrysler #1066278.
2A2704-61B/R15.....	RING: azimuth annulus gear; bearing snap; thin; Chrysler #1066274.
2A2704-61B/R18.....	RING: azimuth main drive; gear snap; thin; Chrysler #1061741.
2A2704-61B/R11.....	RING: azimuth; selsyn drive shaft; bearing snap; ex. thick; outer; Chrysler #1061768.
2A2704-61B/R12.....	RING: azimuth; selsyn drive shaft; bearing snap; inner; Chrysler #1066195.
2A2704-61B/R13.....	RING: azimuth; selsyn drive shaft; bearing snap; thick; outer; Chrysler #1066196.
2A2704-61B/R14	RING: azimuth; selsyn drive shaft; bearing snap; thin; outer; Chrysler #1066194.
2A2704-61B/R26.....	RING: elevation selsyn idler gear snap; Chrysler #1066530.
2A2704-61B/R25.....	RING: retaining; snap spinner motor housing seal spring; Chrysler #1066501.
2A2704-61B/R23.....	RING: slip; Chrysler #1066402.
2A2704-61B/R22.....	RING: snap; elevation selsyn drive shaft bearing; Chrysler #1066350.
2A2704-61B/R20.....	RING: snap; medium; elevation drive main gear hub bearing; Chrysler #1066253.
2A2704-61B/R21.....	RING: snap; thick; elevation drive main gear hub bearing; Chrysler #106 (254).

360. MAINTENANCE PARTS LIST FOR PEDESTAL MP-61-B.

Signal Corps Stock No.	Name of Part and Description
2A2704-61B/R17	RING: snap; thin; elevation drive main gear; Chrysler #1061738.
2A2704-61B/R19	RING: snap; thin; elevation drive main gear hub bearing; Chrysler #1066252.
2A2704-61B/R24	RING: spinner; motor housing floating seal; Chrysler #1066457.
6L4325-1	RIVET: flat head; 5/16" x 1"; Chrysler #104267.
2A2704-61B/R27	ROLLER: elevation drive; idler gear; Chrysler #862155.
6L6440-5. 12S	SCREW: fil. hd. #4-40 x 5/16"; Chrysler #131830.
6L6440-6. 12S	SCREW: fil. hd. #4-40 x 3/8"; Chrysler #131835.
6L6632-4. 12S	SCREW: fil. hd. #6-32 x 1/4"; Chrysler #131882.
6L6632-5. 12S	SCREW: fil. hd. #6-32 x 5/16"; Chrysler #131885.
6L6632-10. 12S	SCREW: fil. hd. #6-32 x 5/8"; Chrysler #131904.
6L6632-20. 12S	SCREW: fil. hd. #6-32 x 1 1/4"; Chrysler #131924.
6L6632-32. 12S	SCREW: fil. hd. #6-32 x 2"; Chrysler #131938.
6L6832-7. 12S	SCREW: fil. hd. #8-32 x 7/16"; Chrysler #131966.
6L6832-8. 12S	SCREW, fil. hd. #8-32 x 1/2"; Chrysler #131970.
6L6832-10. 12S	SCREW: fil. hd. #8-32 x 5/8"; Chrysler #131974
6L7032-16. 12S	SCREW: fil. hd. #10-32 x 1"; Chrysler #132133.
6L7032-36. 47S	SCREW: fh. #10-32 x 2 1/4"; Chrysler #133664.
6L6632-14. 49S	SCREW: rh. #6-32 x 7/8"; Chrysler #132715.
6L7024-5. 49S	SCREW: rh. #10-24 x 5/16"; Chrysler #132825.
6L7032-8. 49S	SCREW: rh. #10-32 x 1/2"; Chrysler #132908.
6L7032-14. 49S	SCREW: rh. #10-32 x 7/8"; Chrysler #132919.
6L7032-16. 49S	SCREW: rh. #10-32 x 1"; Chrysler #132923.
6L7224-7. 49S	SCREW: rh. #12-24 x 7/16"; Chrysler #132972.
6L18235-12. 81C	SCREW: self-tapping; hex. hd. 5/16"-18; Chrysler #1066642.
6L18235-10. 81P	SCREW: self-tapping; hex. hd. 5/16"-18; Chrysler #1066639.
6L18604-8. 43S	SCREW: set; socket; cone point; hex. 1/4"-28 x 1/2"; Chrysler #139349.
6L604-1. 3HC	BOLT: steel; hex. 1/4"-20 x 1 3/8"; Chrysler #121920.
6L604-6HC	BOLT: steel; hex. hd. 1/4"-20; Chrysler #120854.
6L604. 4HC	BOLT: steel; hex. hd. 1/4"-20, 7/16" long; Chrysler #121804.

360. MAINTENANCE PARTS LIST FOR PEDESTAL MP-61-B.

Signal Corps Stock No.	Name of Part and Description
6L604-. 56	BOLT: steel; hex. ¼″-20 x 9/16″; Chrysler #121867.
6L604-. 7HC	BOLT: steel; hex. ¼″-20 x ¾″; Chrysler #121887.
6L604-6HC28	BOLT: steel; hex. hd. ¼″-28 x ⅝″; Chrysler #123435.
6L604-8HC28	BOLT: steel; hex. hd. ¼″-28 x ⅞″; Chrysler #123456.
6L604-1. 2HC28	BOLT: steel; hex. hd. ¼″-28 x 1¼″; Chrysler #123737.
6L605-. 3HC	BOLT: steel; hex. hd. 5/16″-18 x ⅜″; Chrysler #121817.
6L605. 56HC	BOLT: steel; hex. hd. 5/16″-18 x 9/16″; Chrysler #121986.
6L605. 6HC	BOLT: steel; hex. hd. 5/16″-18 x ⅝″; Chrysler #120228.
6L605-. 7HC	BOLT: steel; hex. hd. 5/16″-18 x ¾″; Chrysler #122007.
6L605-. 8HC	BOLT: steel; cap; hex. hd. 5/16″-18 x ⅞″; Chrysler #120229.
6L605-1HZ	BOLT: steel; hex. hd. 5/16″-18 x 1″; Chrysler #122017.
6L605-.56HC24	BOLT: steel; hex. hd. 5/16″-24 x 9/16″; Chrysler #123357.
6L606-.8HC	BOLT: steel; hex. hd. ⅜″-16 x ⅞″; Chrysler #122126.
6L606-1.1HC	BOLT: steel; hex. hd. ⅜″-16 x 1⅛″; Chrysler #122138.
6L604-1.2HC	BOLT: steel; hex. hd. ⅜″-16 x 1¼″; Chrysler #122145.
6L606-1.5HC	BOLT: steel; hex. hd. ⅜″-16 x 1½″; Chrysler #120918.
6L610-1.8HC	SCREW: cap; hex. hd. ⅜″-11 x 1⅞″; Chrysler #122744.
6L608-1.3HC	SCREW: cap; hex. hd. ½″-12 x 1⅜″; Chrysler #122427.
6L608-1.7HC	BOLT: steel; hex. hd. ½″-13 x 1¾″; Chrysler #122446.
6L608-1HC20	BOLT: steel; hex. hd. ½″-20 x 1″; Chrysler #123605.
6L606-.7HC	SCREW: cap; hex. hd.; Chrysler #122119.
6L7032-16.12S	SCREW: azimuth; stowing switch adjustment; Chrysler #132133.
6L2095-21.81C5	SCREW: azimuth; oil reservoir cover; Chrysler #1066642.
6L18604-6.39S	SCREW: azimuth; potentiometer; coupling locking; Chrysler #139347.
6L4904-74C	SCREW: base; adjustment; Chrysler #1066396.
6L7918-5-20.12S	SCREW: telescope; mounting bracket; Chrysler #1061783.
6L7918-5-11.81P	SCREW: spinner motor; generator retainer; locking; Chrysler #1066417.
2A2704-61B/S41	SCREW: oil pump regulator spring; Chrysler #1066156.
6L7919-5-12SPH	SCREW: cross recess; rd. hd. 5/16″-18 x ¾″; Chrysler #155413.

360. MAINTENANCE PARTS LIST FOR PEDESTAL MP-61-B.

Signal Corps Stock No.	Name of Part and Description
6L5027-6P	SCREW: drive; .135–.139 diam x 3/8″; Chrysler #1061791.
2A2704-61B/S53	SCREW: elevation yoke mounting; Chrysler #1066453.
2A2704-61B/S36	SEAL: azimuth; main drive shaft bearing nut; Chrysler #1061745.
2A2704-61B/S35	SEAL: azimuth; main drive shaft gear oil; Chrysler #1066179.
2A2704-61B/S34	SEAL: azimuth; main shaft; upper; Chrysler #1066482.
2A2704-61B/S29	SEAL: azimuth; selsyn drive shaft oil; Chrysler #1066166.
2A2704-61B/S36	SEAL: dust; spinner motor bearing; Chrysler #1066459.
2A2704-61B/S30	SEAL: elevation drive case; Chrysler #1066262.
2A2704-61B/S31	SEAL: elevation; selsyn drive shaft; large; Chrysler #1066281.
2A2704-61B/S33	SEAL: elevation; selsyn drive shaft; small; Chrysler #1066282.
2A2704-61B/S32	SEAL: elevator drive case cover; Chrysler #1061744.
6L58027C	SEAT: azimuth; selsyn adjustment pinion; Chrysler #1066508.
2A2704-61B/S42	SHIELD: azimuth main drive shaft; bearing; Chrysler #1066205.
2A2704-61B/S23	SHIELD: spinner motor and generator housing; Chrysler #1066462.
2A2704-61B/S38	SHIELD: dust; azimuth main shaft; upper bearing; Chrysler #1061809.
2A2704-61B/S28	SHIM: item "P" mounting flange; Chrysler #1061706.
2A2704-61B/S26	SHIM: spinner motor; driving flange; Chrysler #1061707.
2A2704-61B/S27	SHIM: spinner motor; driving flange; Chrysler #1061708.
2A2704-61B/S24	SLEEVE: base; adjustment; Chrysler #1066399.
2Z8552-16	SLEEVE: terminal; Chrysler #926025.
2Z8552-15	SLEEVE: terminal; Chrysler #926026.
2A2704-61B/S51	SPACER: elevation drive idler gear rol.; Chrysler #1066255.
2A2704-61B/S19	SPACER: yoke level mounting; Chrysler #1066485.
2A2704-61B/S20	SPRING: azimuth; oil pump plunger; Chrysler #1066154.
2A2704-61B/S43	SPRING: azimuth; oil pump reg.; Chrysler #1066155.
2A2704-61B/S17	SPRING: azimuth; potentiometer coupling; Chrysler #1066489.
2A2704-61B/S15	SPRING: azimuth; selsyn adjustment pinion; Chrysler #1066356.
2A2704-61B/S16	SPRING: azimuth; selsyn generator final drive anti-backlash; Chrysler #1061754.
2A2704-61B/S21	SPRING: azimuth; selsyn transformer anti-backlash gear; Chrysler #1066355.

Signal Corps Stock No.	Name of Part and Description
2A2704-61B/S48	SPRING: elevation; bell potentiometer gear; Chrysler #1066590.
2A2704-61B/S20	SPRING: elevation; drive oil pump plunger; Chrysler #1066154.
2A2704-61B/S39	SPRING: elevation and azimuth stowing switches; Chrysler #1066420.
2A2704-61B/S43	SPRING: pressure elevation drive oil pump; Chrysler #1066155.
2A2704-61B/S40	SPRING: slip-ring; contact arm; Chrysler #1066360.
2A2704-61B/S25	SPRING: slip-ring; support; Chrysler #1066370.
2A2704-61B/S52	SPRING: spinner motor; housing seal; Chrysler #1061723.
2A2704-61B/S46	STEM: azimuth selsyn; adjustment pinion; Chrysler #1066505.
6L31137-33C	STUD: #3/8–16 x 1″, 7/16″ x 3/8–24; Chrysler #103195.
2Z9611. 101	TRANSFORMER: telescope light; Chrysler pt. #1066321.
2Z9611. 101	TRANSFORMER: pri. 115 volts, sec. 6.3 volts; G. E. cat. #68G541; G. E. dwg. #K-5805499-GB.
2A2704-61B/W2	WASHER: lock; spinner motor locknut; Chrysler #1066481.
6L71004-12C	WASHER: lock; 1/4″; Chrysler #120380.
6L71004-12	WASHER: lock; 1/4″; Chrysler #103319.
6L71004C	WASHER: lock; (light) 1/4″; Chrysler #121637.
6L72514	WASHER: lock; 1/4″ csk; Chrysler #1146-16.
6L71008-2	WASHER: lock; 1/2″; Chrysler #120384.
6L72218C	WASHER: lock, shakeproof, internal 5/16″; Chrysler #138538.
6L71005-7	WASHER: lock; 5/16″; Chrysler #120214.
6L71007C	WASHER: lock; 7/16″; Chrysler #120383.
6L71006C	WASHER: lock; 3/8″; Chrysler #120382.
6L71010C	WASHER: lock; 5/8″; Chrysler #121574.
6L71011C	WASHER: lock; 3/4″; Chrysler #131046.
6L72104C	WASHER: lock; shakeproof; external #4; Chrysler #138468.
6L70006C-1	WASHER: lock; #6; Chrysler #131044.
6L71108C	WASHER: shakeproof; #8; Chrysler #12-1752.
6L7008C. 1	WASHER: lock; (light) #8; Chrysler #13-1182.
6L71008C-1	WASHER: lock; #8; Chrysler #121841.

360. MAINTENANCE PARTS LIST FOR PEDESTAL MP-61-B.

Signal Corps Stock No.	Name of Part and Description
6L70010C	WASHER: lock; #10; Chrysler #120217.
6L71106C	WASHER: lock; shakeproof; external; Chrysler #138473.
6L58027C	WASHER: flat; 3/8" diam; Chrysler #130388.
2A2704-61B/W1	WASHER: azimuth main drive gear; key stop; Chrysler #1066176.
6L58052-3C	WASHER: azimuth main drive; pinion thrust; Chrysler #1061735.
2A2704-61B/G34	WASHER: gasket; spinner motor; seal nut; Chrysler #1061748.
6L58405C	WASHER: azimuth; selsyn drive shaft "O"; Chrysler #1066193.
6L58024-19	WASHER: azimuth selsyn transformer; anti-backlash gear; Chrysler #106616.
6L58422C	WASHER: base adjustment; lock screw; Chrysler #1066398.
6L58403-1C	WASHER: convex; elevation yoke level; Chrysler #1061737.
6L58046-3C	WASHER: elevation drive; idler gear; roller thrust; Chrysler #1066251.
	MISCELLANEOUS
2A2704-61B/C8	ASSEMBLY: azimuth; control housing panel cover, painted; Chrysler #1066516.
2A2704-61B/S5	ASSEMBLY: azimuth; main drive shaft bearing, seal oil; Chrysler #1066640.
2A2704-61B/P4	ASSEMBLY: azimuth; oil pump body; Chrysler #1066233.
2A2704-61B/R2	ASSEMBLY: azimuth; oil reservoir and cover composition; Chrysler #1066184.
2A2704-61B/C11	ASSEMBLY: azimuth; planet pinion carrier; Chrysler #1066583.
2A2704-61B/A1	ASSEMBLY: azimuth; selsyn adjustment pinion; Chrysler #1066439.

APPENDIX A

JAMMING RADIO SET SCR-784

361. GENERAL.

The receiver used in Radio Set SCR-784 is similar basically to the ordinary radio receiver, and responds to signals other than the desired echo signal if these signals occur on the same or nearly the same frequency. Interference may be of natural origin or accidental origin arising from the operation of other electrical or radio equipment. However, the enemy may try to neutralize our radar systems and gain an advantage by deliberately transmitting interfering signals, i.e., jamming. Therefore, it is highly important to be alert to this possibility, to know how to deal with interference, and to obtain the greatest amount of information possible in spite of the jamming. Even if normal returns from targets are obliterated, there is much information to be obtained concerning the jamming. The signals, which may be used for the purpose of jamming our radar systems, may possess any of a large number of characteristics. In general, the oscilloscope indication of the jamming signals occurs at all distances along the circular range line on both range scopes and along the rotating sweep trace of the PPI scope.

362. TYPES OF JAMMING.

There are two major types of jamming; transmission jamming, produced by radio transmitters that create an r-f interference signal, and window jamming, produced by reflectors that reflect an r-f signal. Transmission jamming is the interference produced by a radio transmitter designed to interfere with the normal operation of the radar set. Window jamming uses reflectors, (usually metallic) dropped from aircraft to cause false echoes to appear on the scope screen. They may be used to simulate an airplane echo, or in large quantities to produce a great number of false echoes which conceal the target echoes. All types of transmission jamming may be classified under two categories, continuous-wave (c-w) jamming and modulated jamming. Transmission jamming may saturate the receiver, whereas window jamming while interfering with the normal target echoes never causes saturation.

a. Continuous-wave Jamming.

(*1*) Continuous wave jamming is the transmission of pure r-f signals at a constant amplitude and frequency intended to overload or block the radar receiver, reducing the amplitude or eliminating all target echoes. C-w jamming causes a reduction in the height of the regular target echoes if the signals do not block the receiver and yet may leave no indication of the presence of jamming visible on the range scopes. To all purposes the echoes on the range scopes are reduced and the operator may think the equipment is at fault when actually the set is being jammed. With strong c-w jamming signals, the receiver may be saturated and all target echoes eliminated.

(*2*) However, c-w jamming may be observed on the screen of the PPI scope. The first appearance of weak c-w jamming may be detected on the PPI scope by a brightening of the scope screen sector in the direction of the jammer. The target echoes in that direction are visible, but with a decrease of intensity because of lowered contrast in that sector. With stronger jamming, the target echoes are obliterated in the jammed sector, and the sweep line instead of being clear and sharp becomes very fuzzy and covers a rather large sector, usually the beam width of the set.

b. Modulated Jamming. Modulated jamming transmitters create modulated r-f signals that distort and interfere with the echo signals. As the jamming signals are usually not too heavily modulated they may produce the effects of both c-w and modulated jamming. There are two types of modulation used in modulating jamming transmitters, amplitude-modulation (a-m), and frequency-modulation (f-m). Both

types introduce as many spurious echoes as possible on the scope screen and the modulating signal may be of a very wide variety of waveshapes. The use of these various waveforms containing a large number of frequency components makes it difficult to devise effective antijamming devices. The methods which neutralize c-w jamming do not have too much effect on modulated jamming where the sidebands contain a large number of frequency components. The patterns produced on the scopes by frequency-modulated and amplitude-modulated jamming signals are similar, except that more weaving of the pattern is noticed with f-m. The distortion created by this form of jamming consists of:

(*1*) Low-frequency modulation jamming where the sweepline and echoes of the range scopes move in and out causing concentric circular patterns on the screen. On the PPI scope, a number of lines appear, radiating from the center of the screen toward the outer edge of the sector being jammed. This type is called tram line jamming.

(*2*) Medium-frequency modulation jamming produces a criss-cross or interlaced pattern on the range scopes, and a fuzzy, wide sweep on the PPI scope similar to that caused by c-w jamming.

(*3*) High-frequency modulation or pulse jamming causes either a series of closely spaced vertical spikes or else a rectangular blur to appear on the range scopes depending on the recurrence frequency of the jamming set. The sweep line on the PPI scope is fuzzy and distorted and a series of spiral lines radiate from the center of the scope to the edge. This type is called railings jamming.

(*4*) Modulated jamming can be either spot frequency jamming, barrage jamming, or synchronized jamming. In spot frequency jamming, an interfering jamming signal is produced on only one frequency channel or on a narrow range of frequency and is effective only within its narrow band. Barrage jamming operates over a continuous band of adjacent radio frequencies or channels and jams all radar sets operating within this frequency band. With synchronized jamming the jamming signals appear only over a portion of the circular range line or part of the sweep trace of the PPI scope.

c. Window Jamming. Window jamming is the code name for quantities of metallized paper, either of a square shape, or cut in the form of long strips, which are dropped from aircraft with the intention of producing spurious echoes in radar equipment. For maximum effectiveness the length of the strips should be equal to half the wavelength of the radar set being jammed. Window cut for a given wavelength is somewhat effective against radar equipment using shorter wavelengths but is much less effective when the wavelength is much greater than that for which the window has been cut. When a large amount of window is dropped in a given area, a large number of echoes, all resembling aircraft, appear on the oscilloscope screens of radar sets using the wavelengths being jammed. The window falls relatively slowly, so that its effect remains for long periods after the aircraft have dropped it. The response on an oscilloscope screen from any single batch of window may be characterized by a very heavy beating of the echo which causes the echo to have a saw-tooth appearance. Because of the slow rate of fall, a single batch of window is similar to a fixed echo with the exception of the beating effect, and advantage of this slow movement and appearance aids in distinguishing it from a plane.

363. LOCATION OF JAMMING SOURCE.

As quickly as possible, each unit commander should deliver to the plotting station his azimuth and elevation readings on the interference, and all other information that he is able to obtain. This action is important inasmuch as the information from two or more units may be used to locate the source of interference. Readings on azimuth and elevation should be taken at intervals to ascertain any movement of the source of jamming.

a. Amplitude-modulated Jamming. The directional properties of the antenna determine the direction of the jamming source when saturation does not occur. Jamming signals can be "locked on" in angular coordinates. To cause the SCR-784 to give inaccurate tracking information, modulated jamming, modulated at or near the scanning rate of the SCR-784, is used. In such case, approximate bearings still are obtained by manually scanning for a maximum with or without using conical scan. When the interfering signal is very strong, the location of the jamming transmitter in azimuth and elevation should be determined by observing at what point the height of the pattern on the

32,000-yard range scope is the smallest. The reduction of the pattern height is due to overloading of the receiver when the antenna is turned in the direction of the interference. It may be necessary to adjust the receiver sensitivity so as to make this effect most noticeable.

b. Frequency-modulated Jamming. The method for locating heavy frequency-modulated jamming is essentially the same as for amplitude-modulated jamming. The r-f frequency-modulated signal, when picked up by the radar set, produces output signals of the same shape as the receiver i-f response curve and has a recurrence frequency equal to twice that of the modulation frequency. Thus, the i-f stages actually convert f-m jamming so that it appears as amplitude-modulation to the video circuits.

c. Window Jamming. The fact that a target plane on an incoming course is dropping window is detected first on the fine range scope. Fuzzy echoes, somewhat similar to plane echoes, start at the long range edge of the target echo and drift out to the narrow gate. Soon the effect approaches that of a target echo whose longer range edge is extended to the edge of the narrow gate as a continuous fluttering echo and automatic tracking becomes very erratic.

364. ACTION AGAINST JAMMING.

a. C-w Jamming. When the c-w jamming signal in addition to the target echo is picked up by the radar antenna both signals are fed to the receiving channel. The c-w jamming signal is approximately the same frequency as the received echo and the combination of these two does not change the character of the signal but changes only the level of the signal voltages. The presence of the increased i-f carrier frequency through the action of the AGC circuit, provides an increase in the bias on the receiver stages, and the target echoes gradually diminish. As the strength of the c-w jamming signal is increased, a point is reached where the receiver becomes saturated and all target echoes are eliminated. This type of jamming usually is minimized effectively by manipulating the VOLUME control. In many cases reduction of the gain prevents overloading of the receiver and allows the pip, although reduced in amplitude, to be seen.

b. Amplitude-modulated Jamming. This type of jamming produces an entirely different result than c-w jamming. The waveform of the jamming signal and that of the desired echo pulse add directly in the video circuits of the receiver and the target echo is superimposed on the modulated jamming signal. However, the echo can be seen only if the receiver is not driven to saturation by the modulated signal. Manipulation of the VOLUME control enables the gain of the receiver to be changed and the target echo is seen at least intermittently on the scope. When jamming is intermittent, as with railings, the VOLUME control is usually set very high. This causes the video stages to have a limiting action due to overloading, and may improve the actual echo-to-jamming-signal ratio, as all signals can be amplified only up to the size of the echoes.

c. Frequency-modulated Jamming. When frequency-modulated jamming signals are received, it is important to determine the relative strength of the jamming and whether it is of the spot or barrage frequency type. With frequency-modulated jamming the local oscillator is detuned slightly but the echo is kept visible. If jamming is relatively weak so that it appears in only a small part of the search area, unless there is a marked improvement with only slight detuning, it is not profitable to detune the receiver because of the corresponding loss in performance in other directions. When strong spot-jamming is present, adjustment of the tuning to move the receiver band pass to a new position may shift the frequency enough to miss most of the jamming. However, this also reduces the echo height and the best condition is reached only by trial. Automatic tracking in azimuth and elevation is usually not possible in this case, and manual tracking must be resorted to in getting present position data for the gun directors. With barrage type jamming, it is unlikely that detuning the receiver has much effect. However, the spectrum of the jamming signal is not uniform over its entire band and in the weaker portions of the spectrum it is possible that the target echoes may be observed.

> **CAUTION:** Detuning of the radar set may in some cases shift the effective orientation of the set. The accuracy of the set with the tuning shifted slightly should be checked during periods of inactivity before jamming is encountered.

By using the INTENSITY, FOCUS, and VOLUME controls and changing the range of the scope, it may be possible to improve the definition of the echo signal to the extent that the echo is seen.

d. Window Jamming.

(*1*) Both the range discrimination and narrow beam patterns of the SCR-784 favor the use of this equipment under conditions of window jamming. To minimize the effects of window jamming, the SCR-784 must be set to N^2 gate operation by throwing all ART-NORMAL switches to the ART position and turning on the ART unit power supply. If automatic range tracking was used, the RANGE TRACKING switch should be thrown to MANUAL immediately on the detection of window and aided tracking be used on following the target. Automatic range tracking is not satisfactory because the automatic range tracking circuits cannot distinguish between true and false echoes. The N^2 gate is a 50-yard tracking gate and hence if placed in the proper position with respect to the target, it will exclude all extraneous echoes outside the gate from the servo channel of the receiver and hence the antenna follows the target in azimuth and elevation with little decrease in the smoothness of the data.

(*2*) When the incoming target begins to drop window the N^2 gate, which appears as a bright spot on the 2,000-yard scope, should be positioned on the leading (minimum range) edge of the target echo. This places the target echo in the center of the N^2 gate in the receiver and all extraneous echoes due to window are eliminated from the receiving servo channel.

(*3*) As the plane approaches its minimum range position, there is little range separation between the target echo and the window echo. This makes it impossible to eliminate all window echoes but this condition exists only over a limited range. During this period manual tracking in azimuth and elevation must be used to keep the antenna on target.

(*4*) When the plane leaves the minimum range, the N^2 gate should be shifted to the maximum range side of the echo. If the target turns back and flies through the window the operator must concentrate on keeping the N^2 gate at the maximum range edge of the target. If the tracking in azimuth and elevation is erratic, manual tracking must be used.

(*5*) When window jamming is first detected on the fine range scope, the operator should be prepared to take the following steps:

(*a*) Change the operation of the set from AUTOMATIC to MANUAL tracking if narrow gate (normal) operation is being used. Otherwise follow the procedure given in subparagraphs (1), (2), (3), and (4) above. This change must be made in normal operation because the reception of any echo, other than the target echo being tracked, results in erratic tracking operation and false echoes are tracked instead of tracking the target. Any form of display in which the set is kept automatically on target is influenced by all echoes that appear at approximately the same range. With hand tracking, however, the operator can ignore slightly weaker window signals and continue to follow the aircraft with reasonable accuracy. For this reason any automatic following system becomes inoperative in window before manual operated equipment.

(*b*) Search for targets ahead or above the area filled with window. This step is very important because in almost all raids there is a certain proportion of stragglers, and it may prove profitable to watch the edges of the infected area. Targets outside of the cover of the window field may be tracked and an indication of the course of the planes may be obtained. This aids the operator in keeping approximately on the course of the targets and enables him to be in a position to pick them up under more favorable conditions. If an airplane is dropping window, to screen other aircraft, it cannot conceal its own flight and may be tracked. The efficiency of window may also decrease as the range to the radar set decreases. If tracking a target is difficult or impossible at one place, it may still be possible to track the same target at a later time when it gets closer to the set.

(*c*) Search for targets outside of the area filled with window. The operators should search other areas beside the infected area in case other planes are approaching from different directions. The use of window in a particular sector may be an attempt to make the operators concentrate their attention in that particular area while another raid is made from a different direction.

(*d*) Search through the window carefully for fast moving targets. If a large flight is approaching through a lane being contaminated by window, a sharp watch should be kept for the appearance of individual targets. It is difficult for the enemy to contaminate a large area completely, without leaving holes in the pattern. When batches of window are separated in space, there are breaks in the jamming pattern and planes may be spotted through these holes or open spaces. Special attention should

be paid to the speed of a target plane entering a window-infected area. The range rate should be maintained so that the target can be located after it passes through the area. Even with a heavy concentration of window, operators can still combat the jamming effects by bringing out every possible difference between window and pure target echoes. Attention to range separation, beam separation, flutter, fixity or mobility of echo, manual control, and scanning of the infected area, and manipulation of the VOLUME control may prove successful in reading through window. As in the case of other types of jamming, adjustment of the INTENSITY and FOCUS controls may be helpful in obtaining better definition and improving the contrast between the jamming signal and the target echo.

(*e*) Be prepared to press the COAST button on the panel if the target being tracked drops large quantities of window which are likely to pull the parabola off target.

e. Reference. For further information on antijamming procedures, refer to TM 11-750, Radar Antijamming for the Operator, and TM 11-751, Radar Antijamming for the Technician.

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